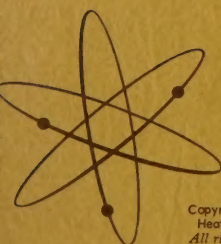


PRICE \$2.00

# HEATHKIT® ASSEMBLY MANUAL



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## SOLID STATE VOM

MODEL IM-25

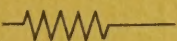

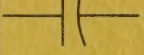
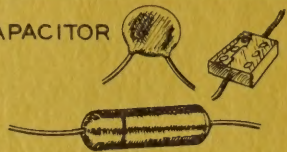

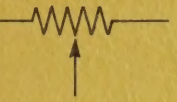
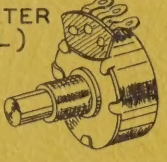
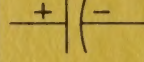
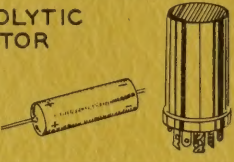
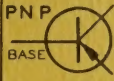
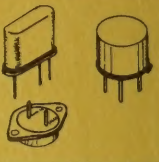
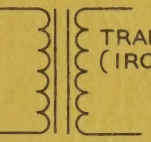
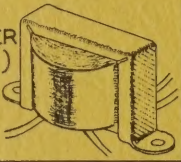
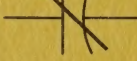

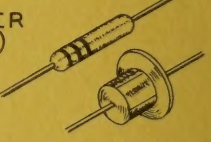
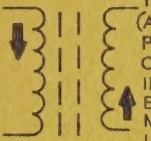

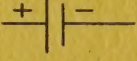

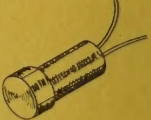
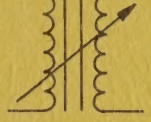
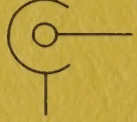
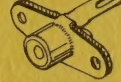

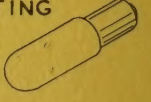
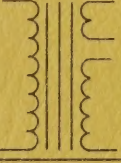
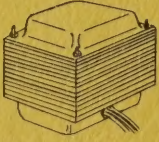
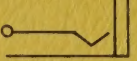
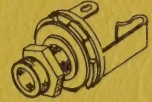
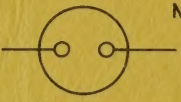

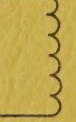
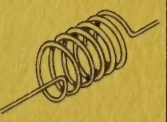
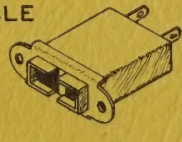
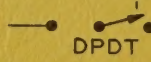
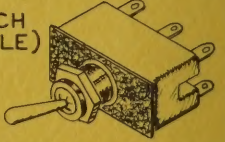
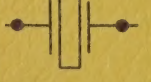

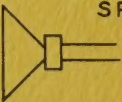

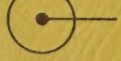
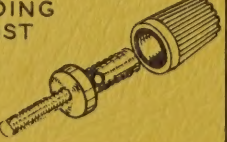
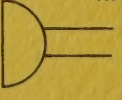
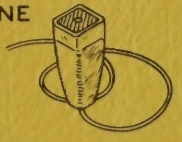
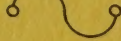
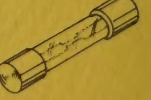


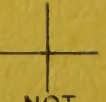
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## TYPICAL COMPONENT TYPES

This chart is a guide to commonly used types of electronic components. The symbols and related illustrations

should prove helpful in identifying most parts and reading the schematic diagrams.

<b>RESISTOR</b>  	<b>CAPACITOR</b>  	 <b>TUBE</b> PLATE SUPPRESSOR SCREEN GRID CATHODE FILAMENT 
<b>POTENTIOMETER (CONTROL)</b>  	<b>ELECTROLYTIC CAPACITOR</b>  	<b>TRANSISTOR</b> PNP BASE COLLECTOR EMITTER NPN BASE COLLECTOR EMITTER   
<b>TRANSFORMER (IRON CORE)</b>  	<b>VARIABLE CAPACITOR</b>  	<b>RECTIFIER (DIODE)</b>  
<b>TRANSFORMER (ADJUSTABLE POWDERED IRON CORE)</b> ARROW INDICATES DIRECTION OF CORE MOVEMENT TO INCREASE INDUCTANCE  	<b>BATTERY</b>  	<b>NEON BULB</b>  
<b>TRANSFORMER (ADJUSTABLE CORE)</b>  	<b>PHONO JACK</b>  	<b>ILLUMINATING BULB</b>  
<b>POWER TRANSFORMER</b>  	<b>PHONE JACK</b>  	<b>METER</b>  
<b>INDUCTOR (COIL)</b>  	<b>RECEPTACLE</b>  	<b>SWITCH (TOGGLE)</b> SPST DPDT   
<b>PIEZOELECTRIC CRYSTAL</b>  	<b>SPEAKER</b>  	<b>SWITCH (ROTARY)</b>  
<b>BINDING POST</b>  	<b>MICROPHONE</b>  	<b>FUSE</b>  
<b>ANTENNA</b> GENERAL  LOOP 	<b>EARTH GROUND</b>  <b>CHASSIS GROUND</b> 	<b>CONDUCTORS</b> NOT CONNECTED  CONNECTED  SHIELDED 

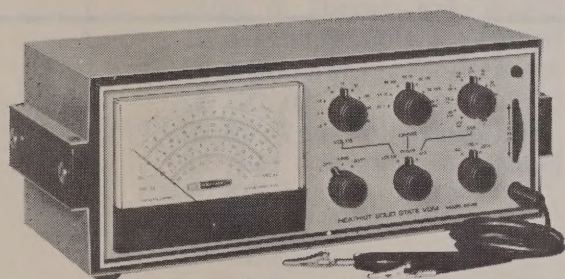


# Assembly and Operation of the



## SOLID STATE VOM

MODEL IM-25



HEATH COMPANY

BENTON HARBOR,  
MICHIGAN 49022

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## INTRODUCTION

The Heathkit Model IM-25 Solid State VOM combines all the features of a vacuum tube voltmeter and a volt-ohm-milliammeter into one attractively styled cabinet. Operation from a 120 volt AC line or from the internal battery is selected by a single switch. The self-contained battery supply allows you to perform all measurement functions at remote locations without an AC power source.

A separate range switch is provided for each of the three functions: Volts, Ohms, and Milliamperes. This makes it possible for each function to have a different number of ranges. Readings are displayed on the large 6-inch meter which has three separate sets of scales. Each set of scales is a different color. For example: all AC voltages are indicated on the red scales, DC voltage on the black scales, and ohms on the green scale.

Additional features of the Solid State VOM include: a low voltage ohmmeter for accurate in-circuit resistance measurement in transistor circuits, a circuit board and cable assembly for easy and clean construction, a single test probe to eliminate tangled test leads, and a dual-winding power transformer that allows you to wire the Voltmeter to operate from either a 120 or 240 volt AC power source.

All of these features combine to provide you with an extremely versatile, accurate, and attractive test instrument that is designed for long and dependable service at minimum cost.

Refer to the "Kit Builders Guide" for complete information on unpacking, parts identification, tools, wiring, soldering, and step-by-step assembly procedures.



## PARTS LIST

To order replacement parts, refer to the Replacement Parts Price List and use the Parts Order Form furnished with this kit.

NOTE: The numbers in parentheses in the Parts List are keyed to the numbers on the Parts Pictorial (fold-out from Page 5).

PART No.	PARTS Per Kit	DESCRIPTION
----------	---------------	-------------

### RESISTORS

#### 1/2 Watt

(1) 1-3	1	100 $\Omega$ (brown-black-brown)
1-4	1	330 $\Omega$ (orange-orange-brown)
1-8	1	820 $\Omega$ (gray-red-brown)
1-11	1	1500 $\Omega$ (brown-green-red)
1-20	1	10 K $\Omega$ (brown-black-orange)
1-21	2	15 K $\Omega$ (brown-green-orange)
1-69	1	18 K $\Omega$ (brown-gray-orange)
1-22	1	22 K $\Omega$ (red-red-orange)
1-23	1	27 K $\Omega$ (red-violet-orange)
1-67	1	39 K $\Omega$ (orange-white-orange)
1-25	2	47 K $\Omega$ (yellow-violet-orange)
1-26	1	100 K $\Omega$ (brown-black-yellow)
1-31	1	330 K $\Omega$ (orange-orange-yellow)
1-32	1	390 K $\Omega$ (orange-white-yellow)

#### Precision 1%

NOTE: Precision resistors may be marked in  $\Omega$ , K $\Omega$ , or M $\Omega$ . K $\Omega$  = 1000  $\Omega$  M $\Omega$  = 1,000,000  $\Omega$ .

(2) 2-94	1	.1 $\Omega$
2-226	1	.2162 $\Omega$
2-225	1	.6838 $\Omega$
2-224	1	2.162 $\Omega$
2-223	1	6.838 $\Omega$
2-219	1	21.62 $\Omega$
2-23	1	68.38 $\Omega$
2-25	1	216.2 $\Omega$

PART No.	PARTS Per Kit	DESCRIPTION
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#### Precision 1%, (cont'd.)

2-28	1	683.8 $\Omega$
2-58	2	1000 $\Omega$ (1K $\Omega$ )
2-31	1	2162 $\Omega$ (2.162 K $\Omega$ )
2-220	1	3162 $\Omega$ (3.162 K $\Omega$ )
2-33	2	6838 $\Omega$ (6.838 K $\Omega$ )
2-50	3	10 K $\Omega$
2-39	2	21.62 K $\Omega$
2-40	1	68.38 K $\Omega$
2-42	1	216.2 K $\Omega$
2-222	1	306.2 K $\Omega$
2-45	1	683.8 K $\Omega$
2-14	2	1 M $\Omega$
2-146	1	2.162 M $\Omega$
2-147	1	6.838 M $\Omega$
2-221	1	9.6838 M $\Omega$
2-17	1	10 M $\Omega$

### CAPACITORS

#### Mica

(3) 20-102	1	100 pf
20-108	1	200 pf
20-113	1	470 pf
20-107	1	680 pf
20-122	1	1000 pf
(4) 20-75	1	5000 pf

#### Other

(5) 21-72	1	.005 $\mu$ fd disc
(6) 23-60	1	.01 $\mu$ fd tubular
(7) 27-47	2	.1 $\mu$ fd Mylar*
(8) 25-54	4	10 $\mu$ fd electrolytic
25-131	1	250 $\mu$ fd electrolytic
(9) 31-30	1	1. 5-7 pf trimmer
31-27	1	8-50 pf trimmer



PART No.	PARTS Per Kit	DESCRIPTION
-------------	------------------	-------------

**CONTROLS-SWITCHES**

(10) 10-52	1	2000 $\Omega$ tab mount control
10-57	2	10 K $\Omega$ tab mount control
10-60	1	500 K $\Omega$ tab mount control
(11) 10-158	1	1000 $\Omega$ control
12-80	1	50 K $\Omega$ dual tandem control
63-430	1	9-position, 3-wafer switch (Volts Range)
63-431	1	3-position, 4-wafer switch (VOA Function)
63-520	1	3-position, 3-wafer switch (AC-DC Mode)
63-433	1	3-position, 1-wafer switch (On-Off Power)
63-434	1	7-position, 1-wafer switch (Ohms Range)
63-435	1	11-position, 1-wafer switch (MA Range)

**PROBE PARTS**

2-14	1	1 M $\Omega$ 1% resistor
(12) 258-53	1	Contact spring
(13) 459-46	1	Switch lever
(14) 459-47	1	Insert insulator
(15) 459-44	1	Front section probe body
(16) 459-45	1	Center section probe body
(17) 459-43	1	Rear section probe body
(18) 477-11	1	Probe tip
(19) 253-51	1	E ring
(20) 256-15	2	Rivet

PART No.	PARTS Per Kit	DESCRIPTION
-------------	------------------	-------------

**DIODES-TRANSISTORS**

(21) 57-27	1	Silicon diode
56-46	1	9.1 volt zener diode
56-32	1	13 volt zener diode
(22) 56-26	4	1N191 crystal diode (brown-white-brown)
(23) 417-118	13	2N3393 transistor
(24) 417-140	2	2N4304 transistor

**METAL PARTS**

90-346-2	2	Cabinet half shell
203-472-1	1	Front panel
203-473-1	1	Rear panel
203-474-1	1	Subpanel
(25) 204-759-1	4	End cap bracket
(26) 204-760-1	2	Side rail bracket
(27) 204-761	2	Circuit board mounting bracket
210-34	1	Front panel bezel
(28) 469-13	2	Battery contactor

**WIRE**

89-23	1	Line cord
134-150	1	Cable assembly
341-1	1	Black test lead
343-11-1	1	Shielded test lead
344-15	1	Black stranded wire
344-16	1	Red stranded wire
344-59	1	Hookup wire







PART No.	PARTS Per Kit	DESCRIPTION
-------------	------------------	-------------

**CONTROLS-SWITCHES**

(10) 10-52	1	2000 $\Omega$ tab mount control
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63-520	1	3-position, 3-wafer switch (AC-DC Mode)
63-433	1	3-position, 1-wafer switch (On-Off Power)
63-434	1	7-position, 1-wafer switch (Ohms Range)
63-435	1	11-position, 1-wafer switch (MA Range)

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(13) 459-46	1	Switch lever
(14) 459-47	1	Insert insulator
(15) 459-44	1	Front section probe body
(16) 459-45	1	Center section probe body
(17) 459-43	1	Rear section probe body
(18) 477-11	1	Probe tip
(19) 253-51	1	E ring
(20) 256-15	2	Rivet

PART No.	PARTS Per Kit	DESCRIPTION
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**DIODES-TRANSISTORS**

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56-32	1	13 volt zener diode
(22) 56-26	4	1N191 crystal diode (brown-white-brown)
(23) 417-118	13	2N3393 transistor
(24) 417-140	2	2N4304 transistor

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203-473-1	1	Rear panel
203-474-1	1	Subpanel
(25) 204-759-1	4	End cap bracket
(26) 204-760-1	2	Side rail bracket
(27) 204-761	2	Circuit board mounting bracket
210-34	1	Front panel bezel
(28) 469-13	2	Battery contactor

**WIRE**

89-23	1	Line cord
134-150	1	Cable assembly
341-1	1	Black test lead
343-11-1	1	Shielded test lead
344-15	1	Black stranded wire
344-16	1	Red stranded wire
344-59	1	Hookup wire



PART PARTS DESCRIPTION  
No. Per Kit

#6 HARDWARE

(29) 250-162	7	6-32 x 1/2" screw
(30) 250-365	8	#6 x 1/4" sheet metal screw
(31) 250-116	15	6-32 x 1/4" screw (black)
(32) 250-229	20	6-32 x 1/4" phillips screw
(33) 250-303	4	6-32 decorative screw
(34) 250-304	4	6-32 x 7/16" spacer stud
(35) 250-305	4	6-32 x 5/16" spacer stud
(36) 252-3	18	6-32 nut
(37) 254-1	13	#6 lockwasher
(38) 259-1	1	#6 solder lug
(39) 259-11	4	Spade lug

OTHER HARDWARE

(40) 250-34	4	4-40 x 1/2" screw
(41) 250-43	1	8-32 x 1/4" setscrew
(42) 252-15	4	4-40 nut
(43) 252-7	8	Control nut
(44) 253-10	12	Control flat washer
(45) 254-9	4	#4 lockwasher
(46) 254-4	2	Control lockwasher
(47) 255-29	4	#4 spacer
(48) 252-73	1	Speednut

MISCELLANEOUS

54-177	1	Power transformer
(49) 73-27	6	Plastic grommet (12 halves)
(50) 75-30	1	Line cord strain relief (for round cord)*
75-71	1	Line cord strain relief (for flat cord)
85-169-1	1	Circuit board
(51) 211-32	2	Handle
(52) 214-21	1	Mercury cell holder
(53) 214-31	4	Battery holder end
352-13	1	Silicone grease

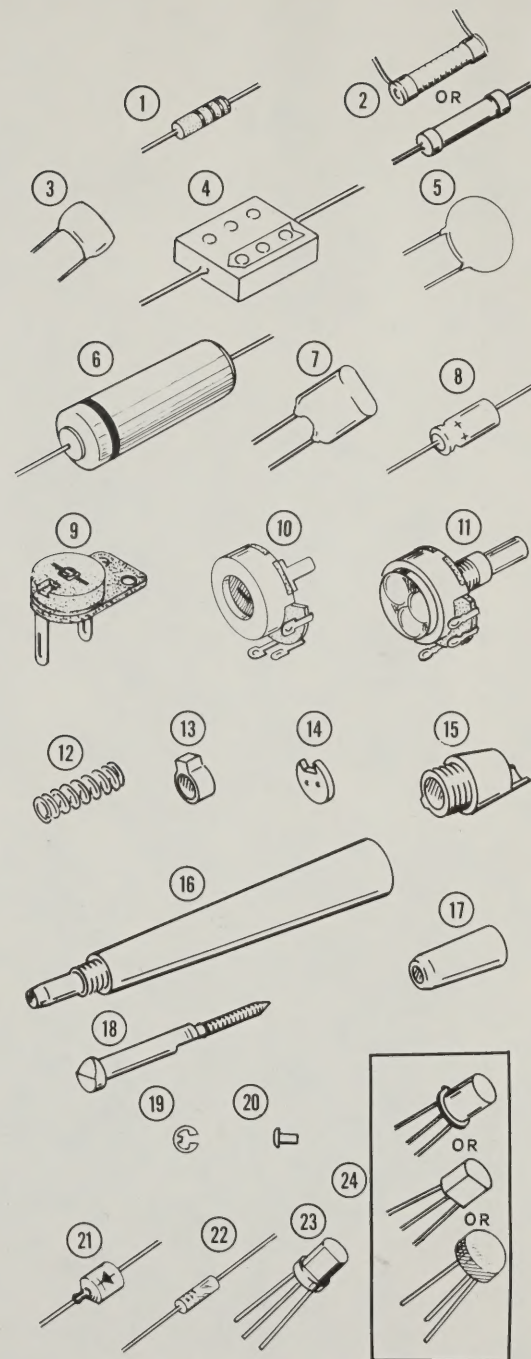
\*This strain relief is supplied to be used in areas mainly outside the U. S., where 2 or 3 wire round cords are required.

PART PARTS DESCRIPTION  
No. Per Kit

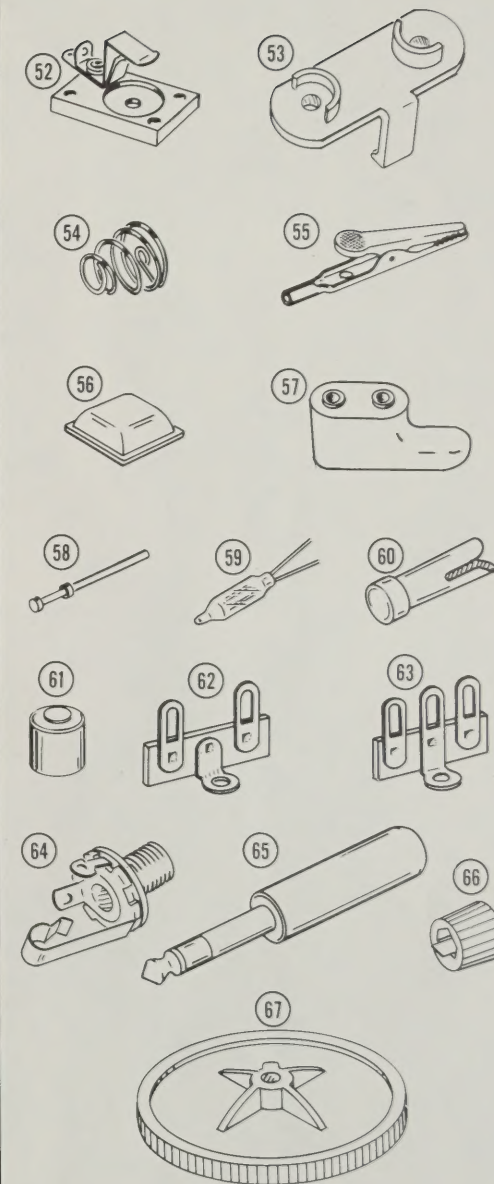
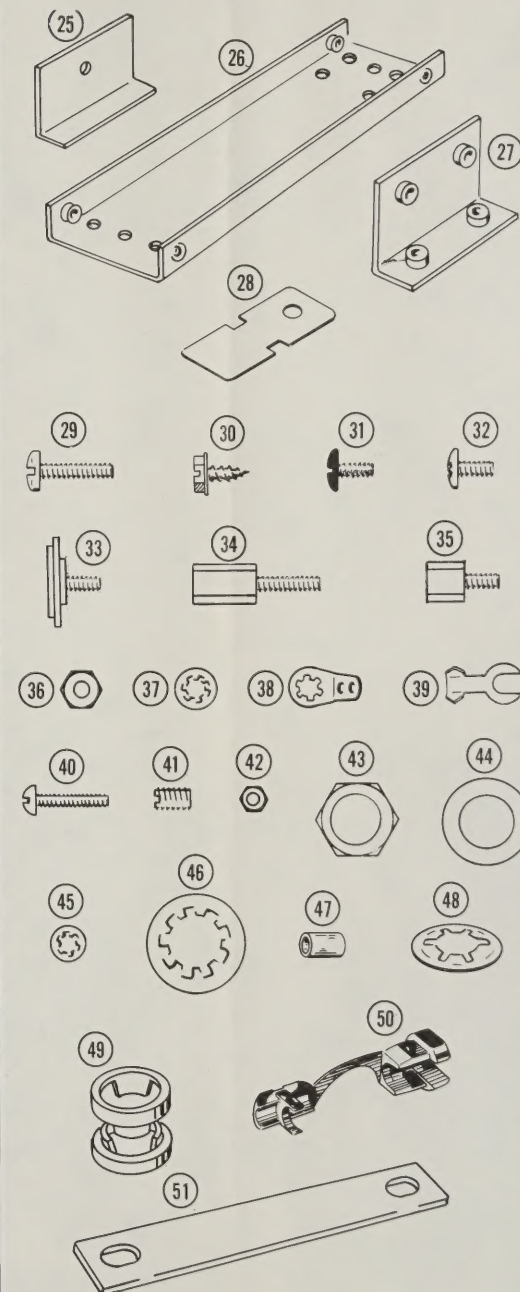
Miscellaneous (cont'd.)

(54) 258-30	4	Battery contact spring
(55) 260-1	1	Alligator clip
	1	Alligator clip with threaded insert
(56) 261-28	4	Plastic foot
(57) 261-30	4	Line cord retainer
(58) 262-8	2	Terminal pin
407-117	1	200 microampere meter
(59) 412-15	1	Neon lamp
(60) 413-10	1	Pilot lamp lens
(61) 418-10	1	Mercury cell
(62) 431-2	1	2-lug terminal strip
(63) 431-10	1	3-lug terminal strip
(64) 436-20	1	Phone jack
(65) 438-28	1	Phone plug
(66) 455-50	6	Knob bushing
462-245	6	Knob
(67) 462-256	1	Thumbwheel knob
432-27	1	Line cord adapter
490-5	1	Nut starter
390-181	1	12-cell battery label
390-182	1	2-cell battery label
391-34	1	Identification label
597-308	1	Kit Builders Guide
597-260	1	Parts Order Form
	1	Manual (See front cover for part number.)
		Solder

NOTE: Fourteen C-cell flashlight batteries (not furnished) will be required for operation of the completed VOM. You may want to purchase these batteries now, to have them ready when you finish assembling the kit. Two of these C-cells must be installed, for both line operation and for battery operation, or the ohms measuring circuit will not operate. The other twelve cells are required for battery operation of the VOM.



PARTS PICTORIAL





## STEP-BY-STEP ASSEMBLY

Before starting to assemble this kit, read the Kit Builders Guide for complete information on wiring, soldering, and step-by-step assembly procedures.

### CIRCUIT BOARD ASSEMBLY

Components will be installed on the circuit board by following the steps on Pictorials 1 through 3. Only a portion of the circuit board is shown in

each Pictorial. The shaded part of the small drawing at the top of each Pictorial shows the area being assembled in the steps on that page.

Position all parts as shown in the Pictorials. All resistors will be called out by only the resistance value (in  $\Omega$ ,  $K\Omega$ , or  $M\Omega$ ); the color code will also be given for color-coded resistors. Capacitors will be called out by only the capacitance value and type. Position the precision resistors with their resistance values up.

#### START



(✓) Locate the circuit board (#85-169-1) and position it lettered side up as shown. The shaded area of the illustration at the top indicates the area of the circuit board being wired in the following steps.

(✓) .005  $\mu$ fd disc. One lead remains on top of the circuit board. It will be connected later.

(✓) 250  $\mu$ fd electrolytic. Position the positive (+) lead of the capacitor as shown by the (+) markings on the circuit board.

(✓) 330  $K\Omega$  (orange-orange-yellow).

(✓) 15  $K\Omega$  (brown-green-orange).

(✓) 1500  $\Omega$  (brown-green-red).

(✓) 10  $K\Omega$  (brown-black-orange).

(✓) 470 pf mica.

(✓) Solder all leads to the foil and cut off the excess lead lengths close to the foil.

(✓) 39  $K\Omega$  (orange-white-orange).

(✓) 1000  $\Omega$  (1  $K\Omega$ ) 1% precision.

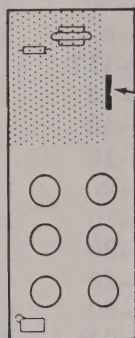
(✓) 10  $K\Omega$  1% precision.

(✓) 27  $K\Omega$  (red-violet-orange).

(✓) 47  $K\Omega$  (yellow-violet-orange).

(✓) 390  $K\Omega$  (orange-white-yellow).

(✓) Solder all leads to the foil and cut off the excess lead lengths.



CIRCUIT BOARD  
NUMBER

#### CONTINUE



(✓) Silicon diode (#57-27). Position the cathode lead as shown. The cathode lead is marked with either a color dot, color band, or color end.



(✓) 15  $K\Omega$  (brown-green-orange).

(✓) 100  $K\Omega$  (brown-black-yellow).

(✓) 1N191 crystal diode. Position the banded end as shown.

(✓) 1N191 crystal diode. Position the banded end as shown.

(✓) 680 pf mica.

(✓) Solder all leads to the foil and cut off the excess lead lengths.

(✓) 1N191 crystal diode. Position the banded end as shown.

(✓) 1N191 crystal diode. Position the banded end as shown.

(✓) 200 pf mica.

(✓) 22  $K\Omega$  (red-red-orange).

(✓) 18  $K\Omega$  (brown-gray-orange).

(✓) 10  $K\Omega$  1% precision.

(✓) 1000  $\Omega$  (1  $K\Omega$ ) 1% precision.

(✓) Solder all leads to the foil and clip off the excess lead lengths.

PICTORIAL 1

PROCEED TO PICTORIAL 2



START

The shaded area in the illustration at the top indicates the area of the circuit board being wired in the following steps.

(✓) Zener diode (#56-46). Shape the cathode lead as shown.



(✓) 820  $\Omega$  (gray-red-brown).

(✓) Zener diode (#56-32). Position the cathode lead as shown.

(✓) 330  $\Omega$  (orange-orange-brown).

(✓) 2,162  $\Omega$  1% precision.

(✓) .6838  $\Omega$  1% precision.

(✓) .2162  $\Omega$  1% precision.

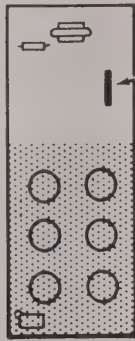
(✓) 10 M $\Omega$  1% precision.

(✓) .1  $\Omega$  1% precision.

(✓) 100  $\Omega$  (brown-black-brown).

(✓) .1  $\mu$ fd Mylar (#27-47).

(✓) Solder all leads to the foil and cut off the excess lead lengths.



CIRCUIT BOARD NUMBER

CONTINUE



(✓) 6,838 M $\Omega$  1% precision.

(✓) 2,162 M $\Omega$  1% precision.

(✓) 683.8 K $\Omega$  1% precision.

(✓) 216.2 K $\Omega$  1% precision.

(✓) 68.38 K $\Omega$  1% precision.

(✓) 21.62 K $\Omega$  1% precision.

(✓) 6838 (6,838 K $\Omega$ ) 1% precision.

(✓) 2162  $\Omega$  (2,162 K $\Omega$ ) 1% precision.

(✓) 683.8  $\Omega$  1% precision.

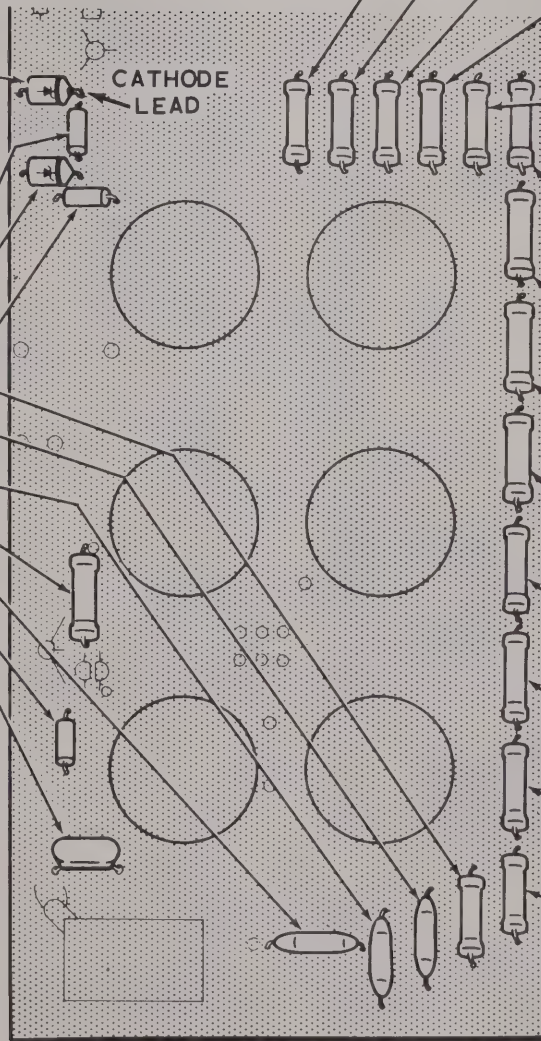
(✓) 216.2  $\Omega$  1% precision.

(✓) 68.38  $\Omega$  1% precision.

(✓) 21.62  $\Omega$  1% precision.

(✓) 6.838  $\Omega$  1% precision.

(✓) Solder all leads to the foil and cut off the excess lead lengths.



PROCEED TO PICTORIAL 3

PICTORIAL 2



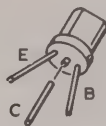
## START



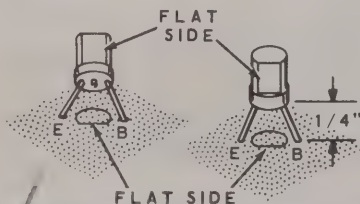
The shaded area in the illustration at the top indicates the area of the circuit board being wired in the following steps.

The transistors will be installed in the following steps. Solder all leads after each transistor is installed. Clip off the excess lead lengths close to the foil.

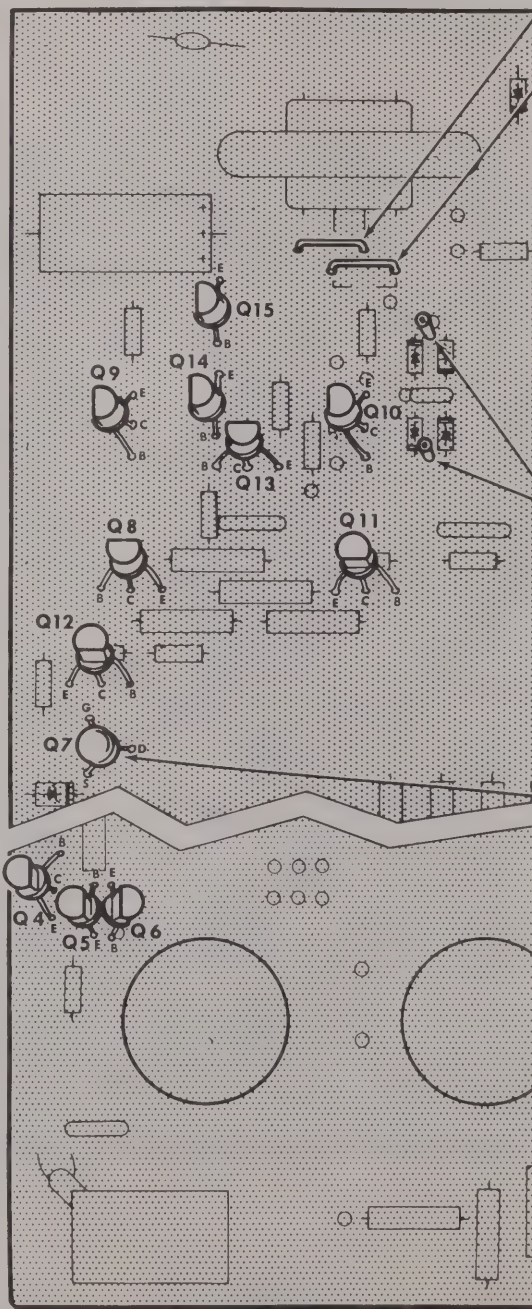
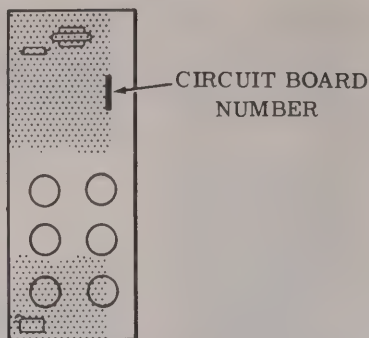
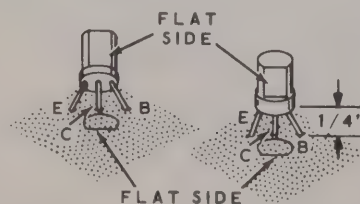
- (✓) Prepare four 2N3393 (#417-118) transistors by clipping off the collector (C) lead. Refer to the illustration below for lead identification.



- (✓) Install the four prepared transistors at locations Q14, Q15, Q5, and Q6. Install the transistors in the following manner, as shown. First line up the flat side of the transistor with the outline of the flat on the circuit board. Then insert the transistor leads into their correct holes, which are indicated by E and B. Mount each transistor about 1/4" above the circuit board.



- (✓) Install 2N3393 transistors at Q4, Q12, Q8, Q9, Q13, Q10, and Q11. Place the base (B), emitter (E), and collector (C) leads in their proper holes as shown below. Be sure to position the flat on the transistor in line with the flat outline on the circuit board.



PICTORIAL 3

## CONTINUE



NOTE: The Solid State VOM can be wired to operate from a 120 volt AC source or a 240 volt AC source. Follow the steps below that apply to your needs.

## 120 VOLT WIRING

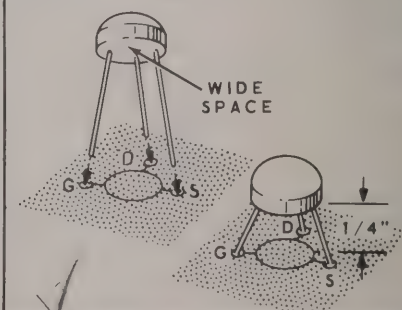
- (✓) 1" bare wire. Use a length of hookup wire with the insulation removed.
- (✓) 1" bare wire.

## 240 VOLT WIRING

- ( ) 3/4" bare wire. Use a length of hookup wire with the insulation removed.

- (✓) Terminal pin. Push pin through until it stops, then solder to foil and clip off excess.

- (✓) Install a 2N4304 (#417-140) transistor at Q7 in the following manner, as shown: Line up the wide space between the G and S transistor leads with the correct circuit board holes. Then insert the transistor leads as shown into the holes and position the transistor 1/4" away from the circuit board. Solder each lead to the foil and cut off the excess lead lengths.



- (✓) Be sure all leads are soldered to the foil and clip off all excess lead lengths.

PROCEED TO PICTORIAL 4

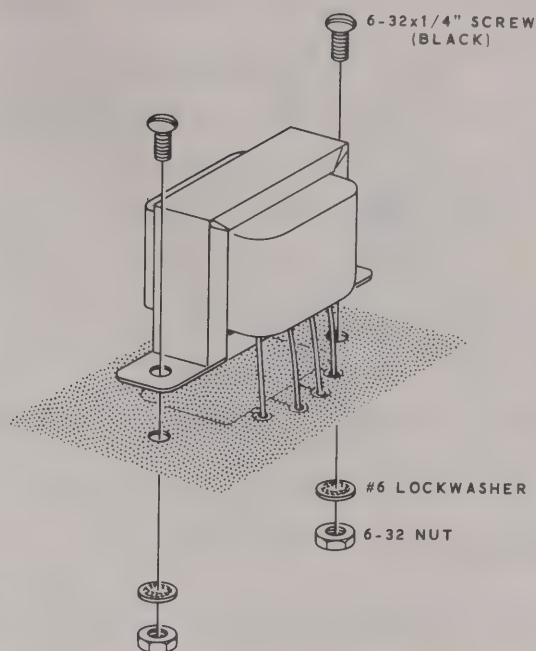


## CABLE ASSEMBLY WIRING AND CIRCUIT BOARD PARTS MOUNTING

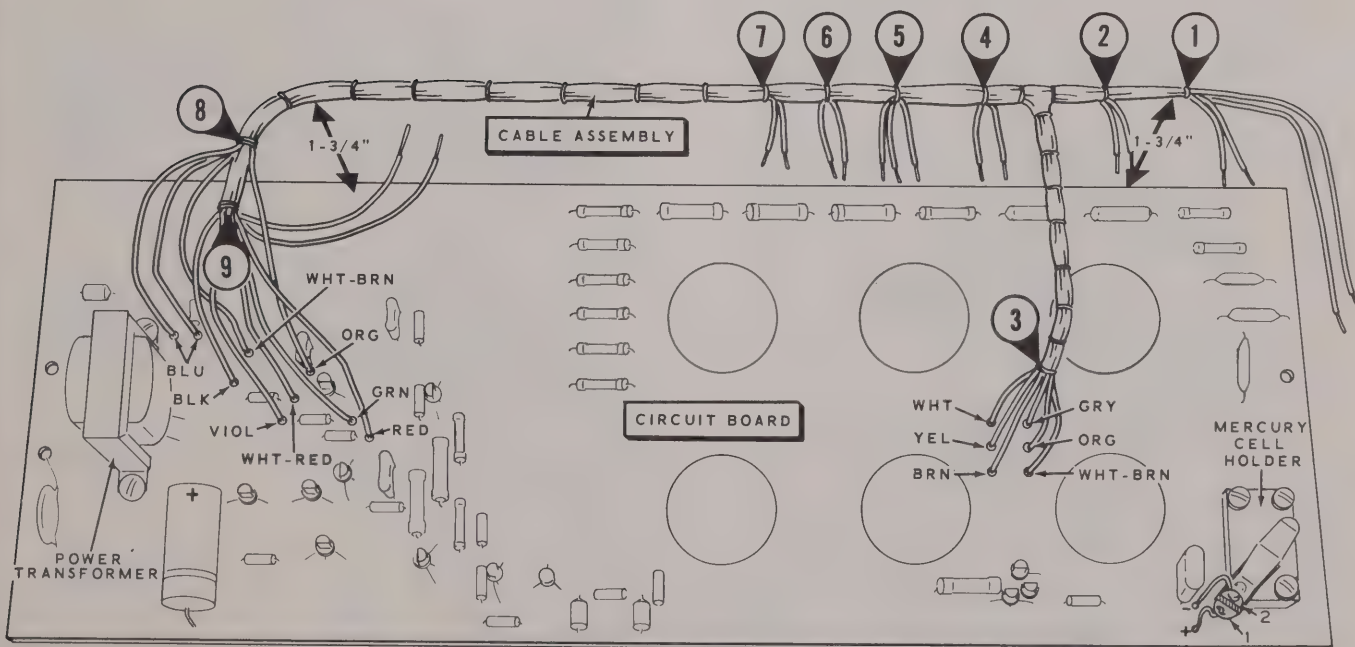
Refer to Pictorial 4 for the following steps.

NOTE: The Heath Company has provided a plastic nut starter with this kit. Use this nut starter to hold and start 6-32 and 4-40 nuts on screws. Refer to Page 3 of the Kit Builders Guide for further information.

(✓) Refer to Detail 4A and install the power transformer #54-177 on the circuit board. Place each wire from the transformer through the corresponding hole in the circuit board. Secure the transformer with two 6-32 x 1/4" black screws, #6 lockwashers, and 6-32 nuts. Solder each lead to the circuit board foil and cut off the excess lead lengths.



Detail 4A



PICTORIAL 4





(4) Refer to Detail 4B and mount the mercury cell holder on the circuit board. Use 6-32 x 1/2" screws, #6 lockwashers, and 6-32 nuts.

wife  
~~(X)~~

- ( ) ~~X~~ a



### Detail 4B



- ( ) Locate the cable assembly (#134-150) and position it over the circuit board as shown in Pictorial 4. Breakout #1 has only two long and two short wires, while breakout #9 at the other end of the cable assembly has seven wires. Notice that after the cable assembly is wired to the circuit board, it is positioned 1-3/4" above the top edge of the circuit board.

Place each cable assembly wire through the circuit board hole as called out in the following steps. Bend each lead slightly to hold it in place until all wires from the same breakout are connected. Then solder each wire and clip off the excess length.

Connect the wires from breakout #3 to the circuit board as follows:

- ( ) White-brown wire to the WHT-BRN hole.
- ( ) Orange wire to the ORG hole.
- ( ) Gray wire to the GRY hole.
- ( ) Brown wire to the BRN hole.
- ( ) Yellow wire to the YEL hole.
- ( ) White wire to the WHT hole.
- ( ) Solder all wires to the foil and cut off the excess wire.

Connect the wires from breakout #8 as follows:

- ( ) Either blue wire to either BLU hole.
- ( ) Remaining blue wire to the remaining BLU hole.
- ( ) White-brown wire to the WHT-BRN hole.
- ( ) Orange wire to the ORG hole.
- ( ) Solder all wires to the circuit board and cut off the excess wire.

Connect the wires from breakout #9 as follows:

- ( ) White-red wire to the WHT-RED hole.
- ( ) Violet wire to the VIOL hole.
- ( ) Green wire to the GRN hole.
- ( ) Red wire to the RED hole.
- ( ) Black wire to the BLK hole.

NOTE: The yellow and white wires from breakout #9 will be connected later.

- ( ) Solder all wires to the circuit board and cut off the excess wire.
- ( ) Position the cable assembly so it is 1-3/4" above the circuit board as shown in Pictorial 4.
- ( ) Set the circuit board aside until it is called for later in the assembly.



## SWITCH PREWIRING

Refer to Pictorial 5 for the following steps.

- (✓) Locate the Volts Range switch (#63-430).

NOTE: The Volts Range switch will be referred to in the following steps as switch K.

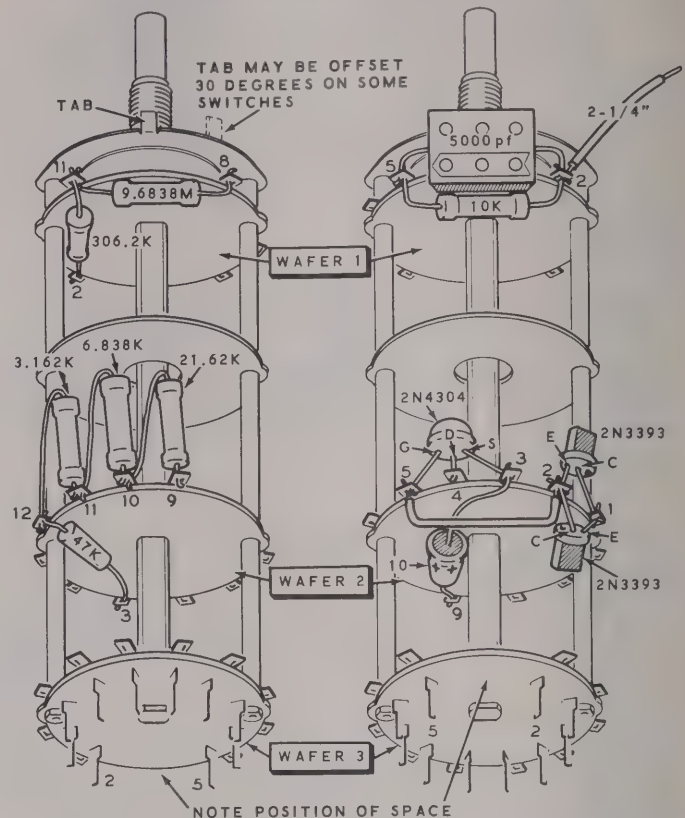
The following system will be used to identify switches, wafers, and lug numbers. The first letter will identify the switch; the first number that follows will identify the wafer; and the second number will identify the lug. The term K1-2, for example, would be interpreted as follows: K = the Volts Range switch; 1 = wafer #1 of this switch; -2 = lug #2 of this wafer. Use Pictorial 5 to identify wafers and lug numbers for switch K. Note the position of the wide space between lugs 2 and 5 of wafer 3.

- (✓) Connect a 306.2 K $\Omega$  precision resistor between K1-2 (NS) and K1-11 (NS).
- (✓) Connect a 9.6838 megohm precision resistor between K1-8 (NS) and K1-11 (NS).
- (✓) Connect a 10 K $\Omega$  precision resistor between K1-2 (NS) and K1-5 (NS).
- (✓) Connect a 5000 pf mica capacitor between K1-2 (NS) and K1-5 (NS).
- (✓) Connect one end of a 2-1/4" wire to K1-2 (S-4). Leave the other end free; it will be connected later.

NOTE: In the next three steps, position each resistor as shown in Pictorial 5.

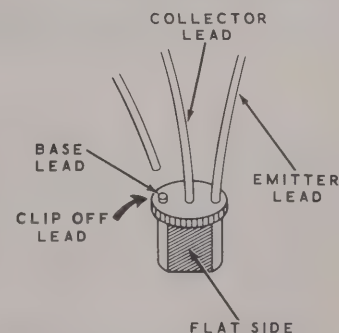
- (✓) Connect a 21.62 K $\Omega$  precision resistor between K2-9 (NS) and K2-10 (NS).
- (✓) Connect a 6.838 K $\Omega$  precision resistor between K2-10 (S-2) and K2-11 (NS).
- (✓) Connect a 3.162 K $\Omega$  precision resistor between K2-11 (S-2) and K2-12 (NS).
- (✓) Connect a 47 K $\Omega$  (yellow-violet-orange) resistor between K2-12 (NS) and K2-3 (NS).
- (✓) Connect the positive (+) lead of a 10  $\mu$ fd electrolytic capacitor to K2-3 (NS) and the other lead of this capacitor to K2-9 (NS).
- (✓) Connect a 2" wire between K2-2 (NS) and K2-5 (NS).

## VOLTS RANGE SWITCH K (#63-430)



## PICTORIAL 5

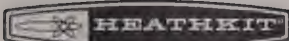
- (✓) Refer to Detail 5A and clip off the base lead of a 2N3393 transistor.



## Detail 5A

- (✓) Position the flat side of the prepared transistor as shown in Pictorial 5; then connect the emitter lead to K2-2 (NS) and the collector lead to K2-1 (NS).
- (✓) Prepare another 2N3393 transistor by clipping off the base lead as shown in Detail 5A.



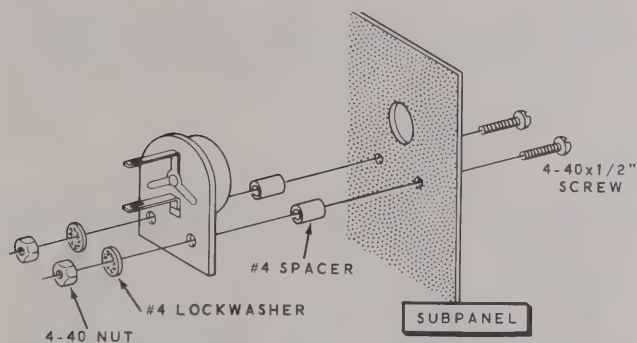


- (✓) Connect the emitter lead of this prepared transistor to K2-1 (NS) and the collector lead to K2-2 (S-3).
- (✓) Position a 2N4304 transistor so the wide space between the G (gate) and S (source) leads is as shown in Pictorial 5. Then connect the source lead to K2-3 (S-3), the drain lead to K2-4 (NS), and the gate lead to K2-5 (NS).

### SUBPANEL ASSEMBLY AND WIRING

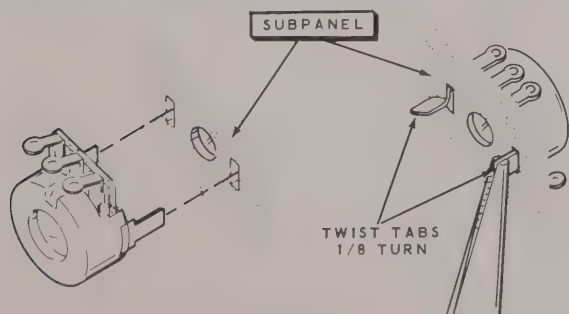
Refer to Pictorial 6 for the following steps.

- (✓) Position the subpanel (#203-474-1) as shown.
- (✓) Refer to Detail 6A and mount an 8-50 pf ceramic trimmer capacitor (#31-27) at B on the subpanel. Use 4-40 x 1/2" screws, #4 spacers, #4 lockwashers, and 4-40 nuts.

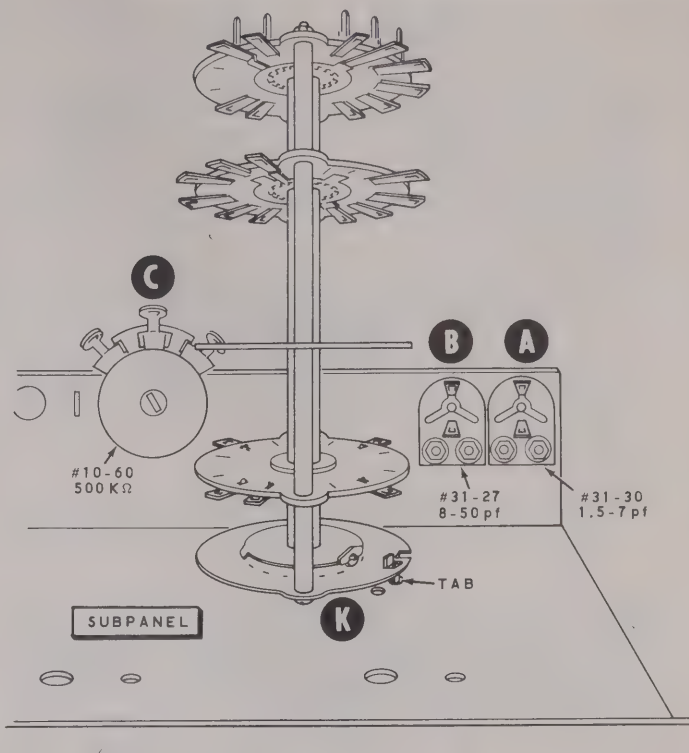


Detail 6A

- (✓) Similarly, mount a 1.5-7 pf ceramic trimmer capacitor (#31-30) at A. Use 4-40 x 1/2" screws, #4 spacers, #4 lockwashers, and 4-40 nuts.
- (✓) Refer to Detail 6B and mount a 500 KΩ control (#10-60) at C. Secure the control by twisting the mounting tabs 1/8 turn.

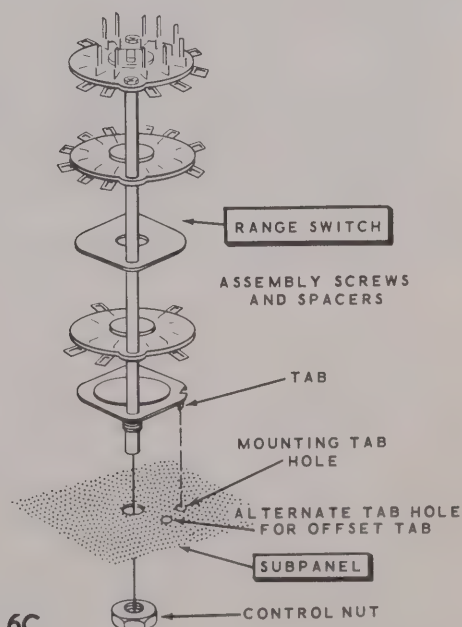


Detail 6B



PICTORIAL 6

- (✓) Refer to Detail 6C and temporarily mount the prewired Volts Range switch at K. Position the mounting tab in the appropriate small hole as shown. Note that the switch supplied with your kit may have a tab that is offset 30 degrees. In that case, use the offset small hole and be sure the assembly screws and spacers are parallel with the end of the panel. Secure the switch temporarily with a control nut.



Detail 6C







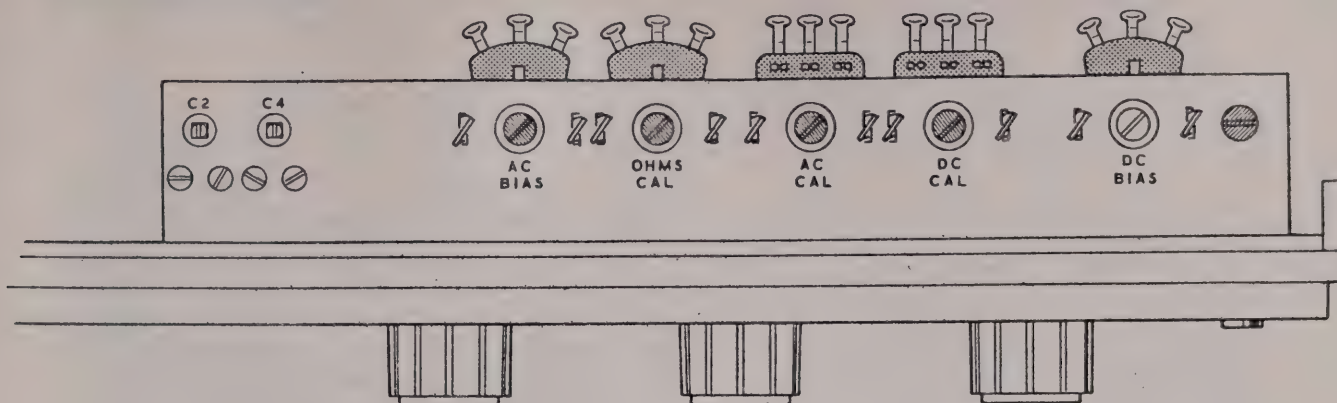


Figure 2

NOTE: In the following steps, you will recheck the DC calibration of the VOM.

- (X) Turn the AC-DC MODE switch to the DC+ position and turn the Volts Range switch to the 1.5 positions.
- (X) Turn the test probe switch to DC.
- (X) Connect the common (black) test lead to the minus (-) lead and the tip of the test probe to the positive (+) lead of the mercury cell holder mounted on the circuit board.
- (X) Adjust the DC CAL control until the meter indicates exactly 1.35 volts on the 1.5 volt DC scale.
- (X) Disconnect the test probe and test lead from the mercury cell holder.

NOTE: The small red dot at the right-hand end of the 15 DC scale represents 1.55 volts when

the VOLTS Range switch is in the 1.5 position. Fully-charged, unused dry cell batteries should measure 1.55 volts DC. This offers a convenient way to check DC calibration at any time.

### AC CALIBRATION

The AC calibration of your Solid State VOM consists of the following: the AC Bias control adjustment, AC Calibration control adjustment, and the adjustment of the AC frequency compensating trimmer capacitors, C2 and C4. The AC Bias and AC Calibration adjustments can be made quite accurately without special equipment. However, for maximum accuracy, and for the adjustment of the AC frequency compensating trimmers, an AC and DC voltmeter, an audio square-wave generator, and an oscilloscope, will be required.

### AC Bias Control Adjustment

- ( ) Turn the VOA Function switch to the VOLTS position, and the AC-DC Mode switch to DC-.
- ( ) Turn the VOLTS Range switch to the 5 position.







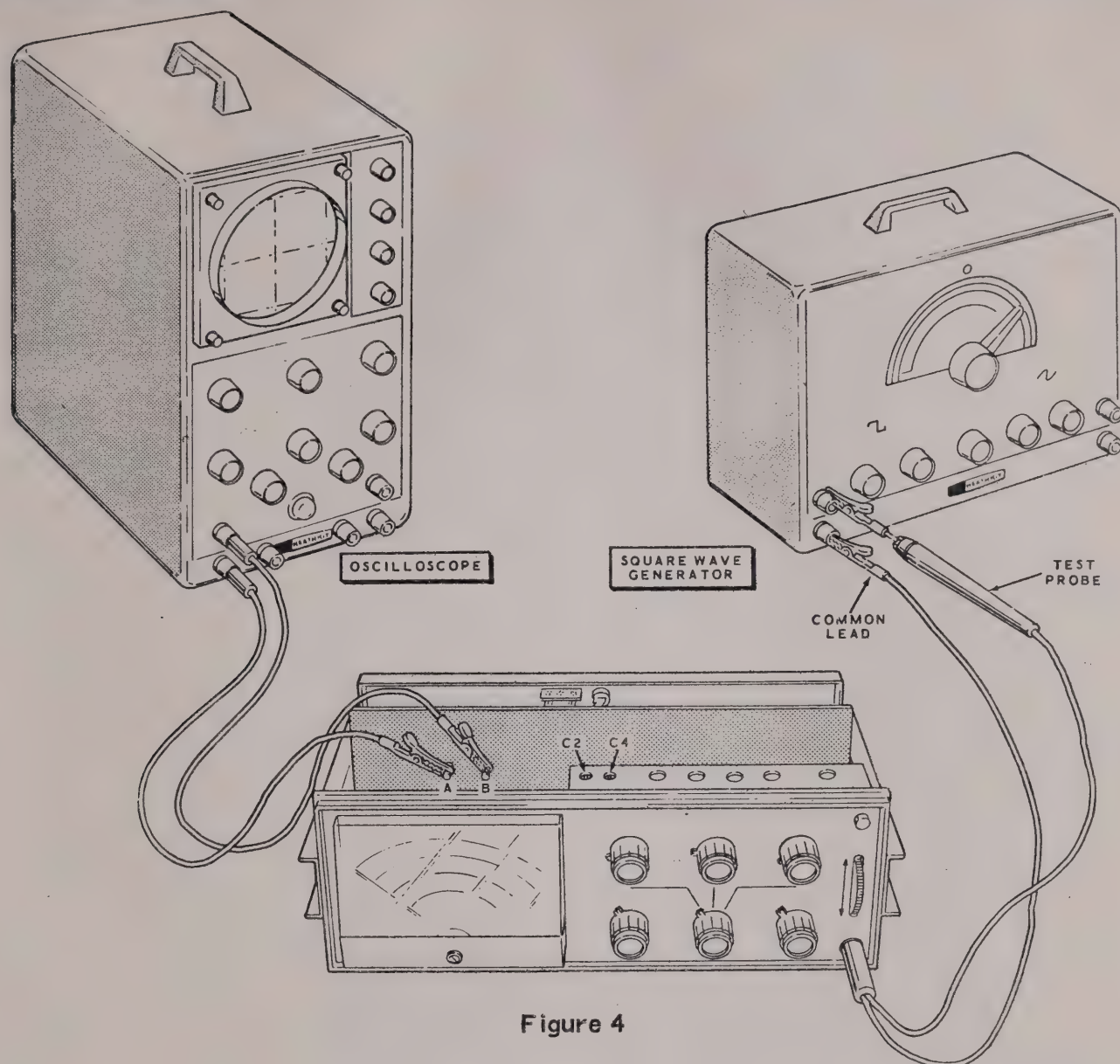


Figure 4

- ( ) Disconnect the test probe and common lead from the calibrating voltage.

### Frequency Compensating Trimmer Adjustment

This adjustment improves the accuracy of voltage measurements at higher frequencies. It compensates for capacitive effects of the probe and circuits for different AC voltage ranges. An audio square-wave generator and an oscilloscope are required to properly adjust the frequency compensating trimmer capacitors.

**NOTE:** If an audio square-wave generator and an oscilloscope are not available, and only average accuracy at higher frequencies will satisfy your

needs, set trimmer capacitors C2 and C4 so their slots are perpendicular (at right angles) to the front panel. Then, omit the following Frequency Compensating Trimmer Adjustments and proceed to Ohms Calibration.

Refer to Figure 4 for the following steps.

- ( ) Connect the input of an oscilloscope to terminal pins A and B on the circuit board.
- ( ) Be sure the VOM test probe switch is in the AC-OHMS position.
- ( ) Connect the VOM test probe and common test lead to the square-wave output of the audio generator.







24, 25, 26, 27

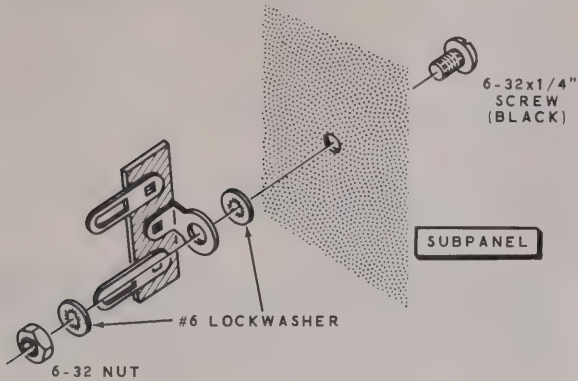
178

11X

20

11

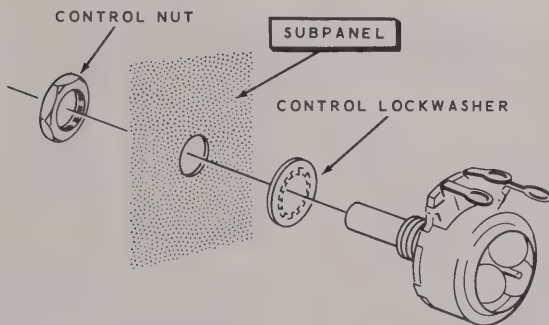




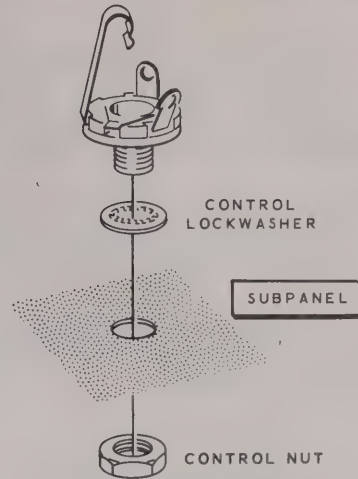
Detail 8A

Refer to Pictorial 8 (fold-out from this page) for the following steps.

- (✓) Refer to Detail 8A and mount a 2-lug terminal strip at H. Use a 6-32 x 1/4" black screw, two #6 lockwashers, and a 6-32 nut.
- (✓) Refer to Detail 8B and mount a 1000  $\Omega$  control (#10-158) at S. Use a control lockwasher and a control nut. Position the control lugs as shown.



Detail 8B

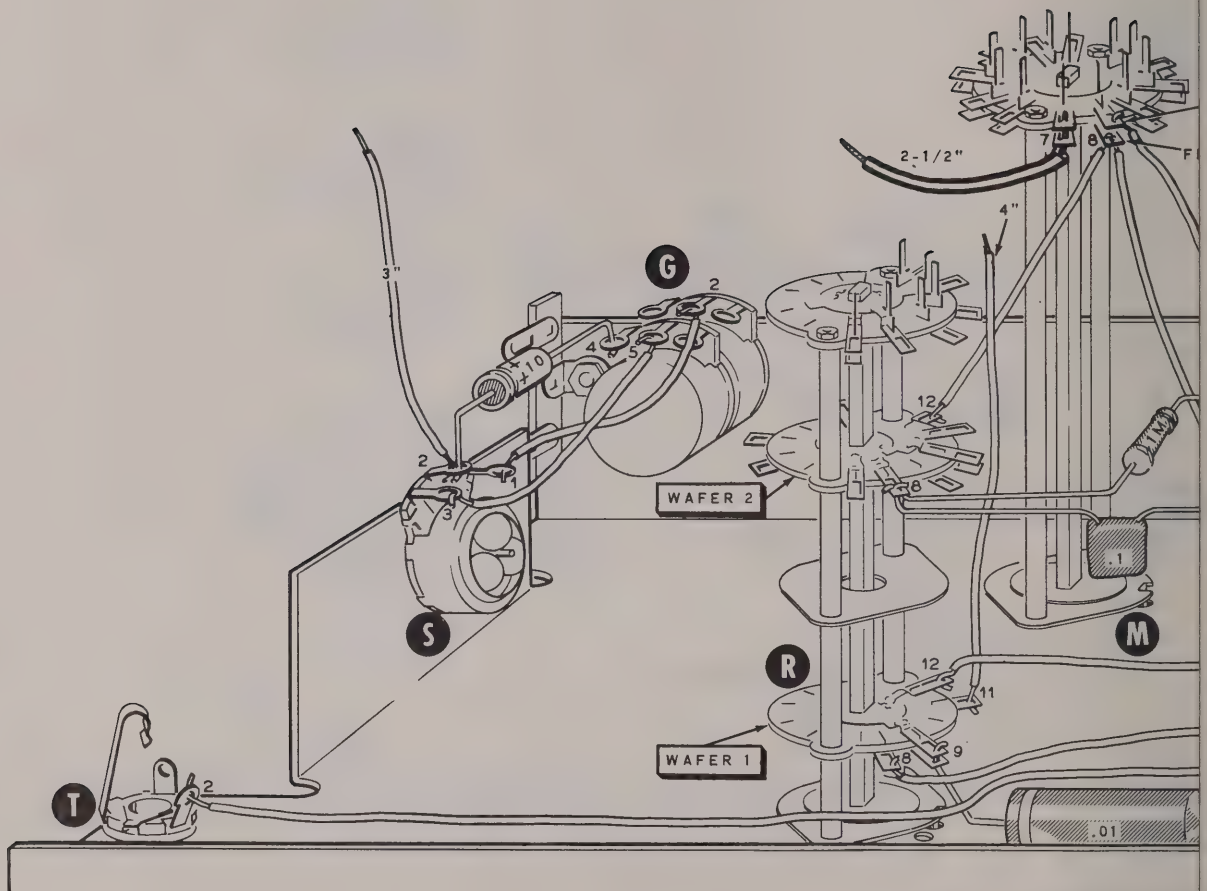


Detail 8C

- (✓) Refer to Detail 8C and mount a phone jack at T. Use a control lockwasher and a control nut. Position the jack lugs as shown.

NOTE: As you mount the switches in the next three steps, place the locating tab on each switch in the small hole beside the mounting hole.

- (✓) Temporarily mount the VOA Function switch (#63-431) at P with a control nut.
- (✓) Temporarily mount the AC-DC Mode switch (#63-520) at R with a control nut.
- (✓) Temporarily mount the MA Range switch (#63-435) at M with a control nut.
- (✓) Mount a 50 K $\Omega$  dual tandem control (#12-80) at G. Secure the control by twisting each mounting tab 1/8 turn.



PICTO

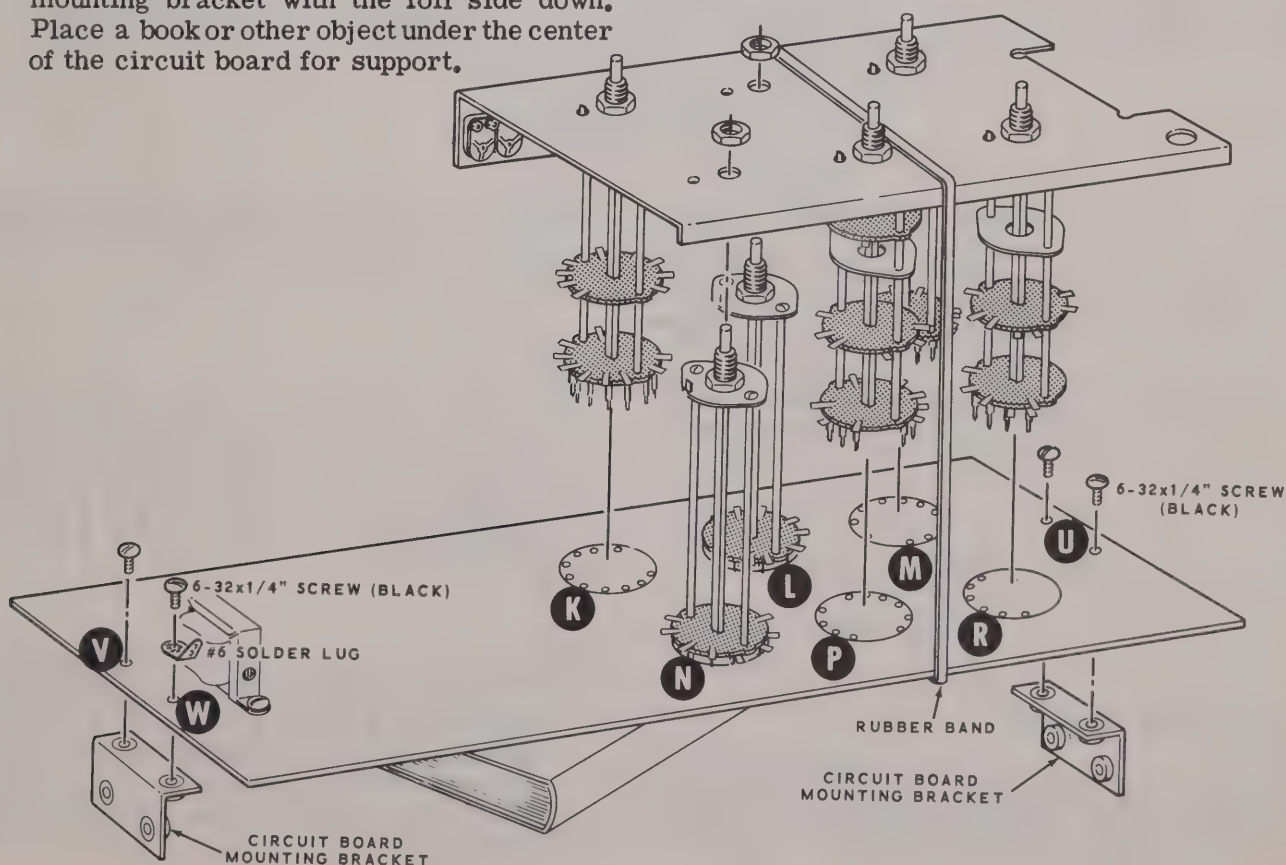


- (✓) Connect a 1-1/4" wire from R2-9 (S-1) to P3-4 (S-1).
- (✓) Connect a 2-3/4" wire from R2-7 (S-1) to P3-7 (S-1).
- (✓) Connect a 2-1/4" wire from P3-12 (S-1) to K2-6 (S-1).
- (✓) Connect a 3-1/2" wire from P3-10 (S-1) to K2-9 (S-3).

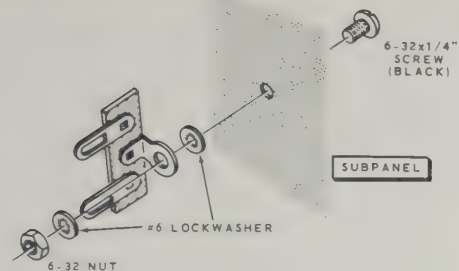
Refer to Pictorial 11 for the following steps.

- (✓) Position the circuit board as shown in Pictorial 11.
- (✓) Mount a circuit board mounting bracket at U on the foil side of the circuit board. Use two 6-32 x 1/4" black screws.
- (✓) Mount a circuit board mounting bracket at V on the foil side of the circuit board and a #6 solder lug at W on the component side of the board. Use two 6-32 x 1/4" black screws.
- (✓) Set the circuit board on the circuit board mounting bracket with the foil side down. Place a book or other object under the center of the circuit board for support.

- (✓) Mount the On-Off Power switch (#63-433) on the circuit board at N by inserting the lugs through the holes on the circuit board. Do not solder at this time.
- (✓) Similarly, mount the Ohms Range switch (#63-434) on the circuit board at L. Do not solder at this time.
- (✓) Place the subpanel above the circuit board and line up the switch lugs on switches K, M, P, and R with their respective holes in the circuit board.
- (✓) Lower the subpanel and switches until the switch lugs pass through the circuit board and the bushings of switches L and N pass through the subpanel. Temporarily secure switches L and N to the subpanel with control nuts. Do not solder the switches to the circuit board foil.
- (✓) Place a large rubber band around the subpanel and circuit board to hold the assembly together until the switch lugs are soldered in a later step.



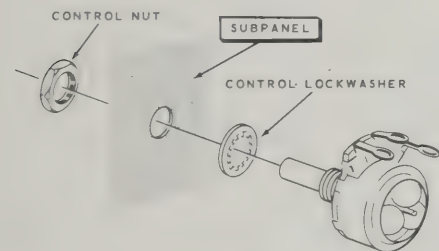
PICTORIAL 11



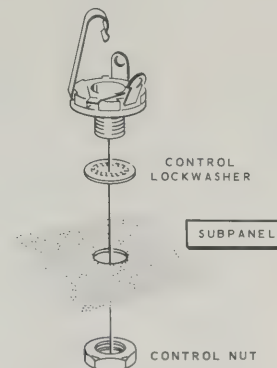
Detail 8A

Refer to Pictorial 8 (fold-out from this page) for the following steps.

- (✓) Refer to Detail 8A and mount a 2-lug terminal strip at H. Use a 6-32 x 1/4" black screw, two #6 lockwashers, and a 6-32 nut.
- (✓) Refer to Detail 8B and mount a 1000  $\Omega$  control (#10-158) at S. Use a control lockwasher and a control nut. Position the control lugs as shown.



Detail 8B

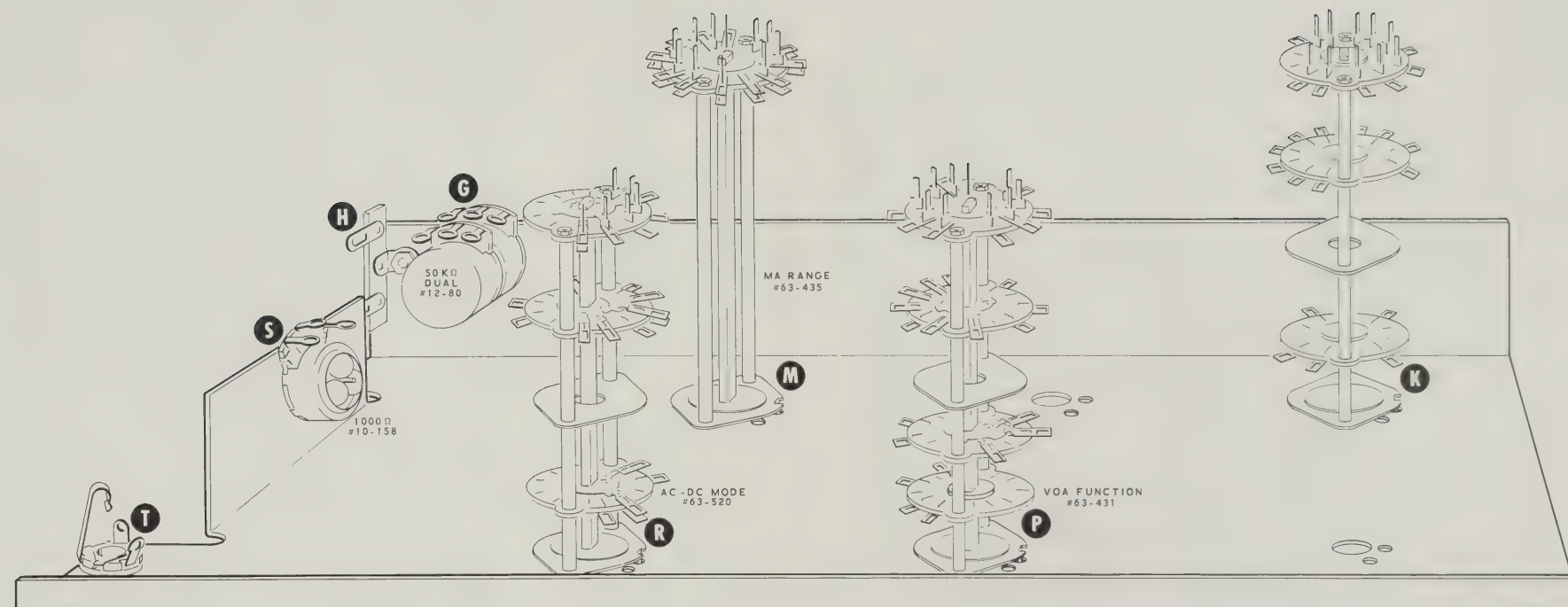


Detail 8C

- (✓) Refer to Detail 8C and mount a phone jack at T. Use a control lockwasher and a control nut. Position the jack lugs as shown.

NOTE: As you mount the switches in the next three steps, place the locating tab on each switch in the small hole beside the mounting hole.

- (✓) Temporarily mount the VOA Function switch (#63-431) at P with a control nut.
- (✓) Temporarily mount the AC-DC Mode switch (#63-520) at R with a control nut.
- (✓) Temporarily mount the MA Range switch (#63-435) at M with a control nut.
- (✓) Mount a 50 K $\Omega$  dual tandem control (#12-80) at G. Secure the control by twisting each mounting tab 1/8 turn.



PICTORIAL 8

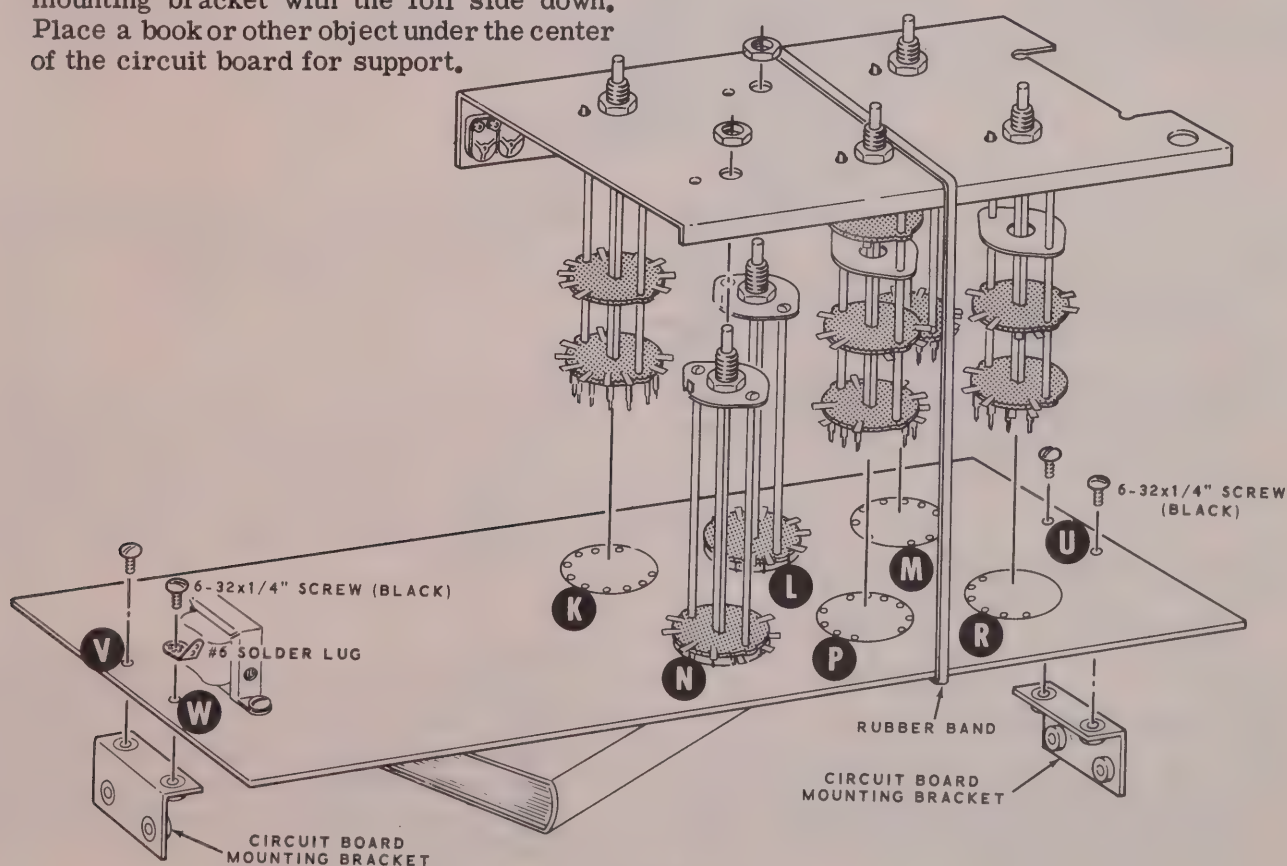


- (✓) Connect a 1-1/4" wire from R2-9 (S-1) to P3-4 (S-1).
- (✓) Connect a 2-3/4" wire from R2-7 (S-1) to P3-7 (S-1).
- (✓) Connect a 2-1/4" wire from P3-12 (S-1) to K2-6 (S-1).
- (✓) Connect a 3-1/2" wire from P3-10 (S-1) to K2-9 (S-3).

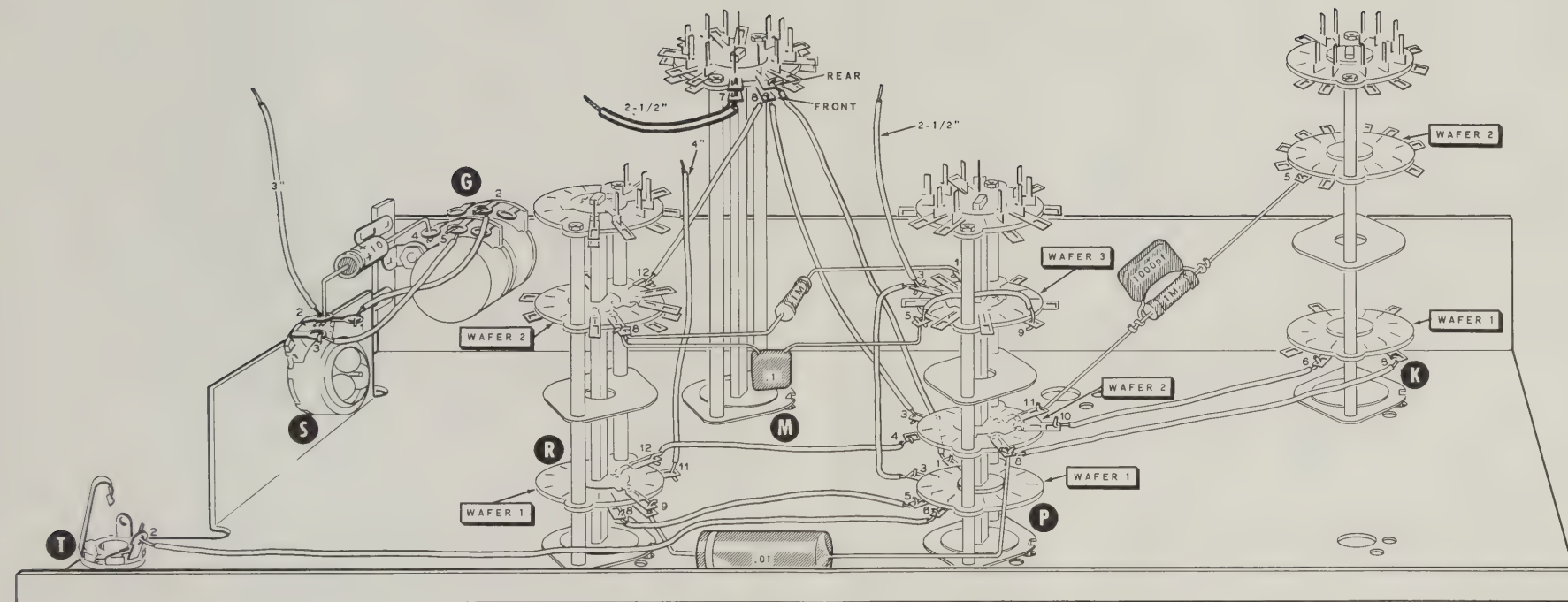
Refer to Pictorial 11 for the following steps.

- (✓) Position the circuit board as shown in Pictorial 11.
- (✓) Mount a circuit board mounting bracket at U on the foil side of the circuit board. Use two 6-32 x 1/4" black screws.
- (✓) Mount a circuit board mounting bracket at V on the foil side of the circuit board and a #6 solder lug at W on the component side of the board. Use two 6-32 x 1/4" black screws.
- (✓) Set the circuit board on the circuit board mounting bracket with the foil side down. Place a book or other object under the center of the circuit board for support.

- (✓) Mount the On-Off Power switch (#63-433) on the circuit board at N by inserting the lugs through the holes on the circuit board. Do not solder at this time.
- (✓) Similarly, mount the Ohms Range switch (#63-434) on the circuit board at L. Do not solder at this time.
- (✓) Place the subpanel above the circuit board and line up the switch lugs on switches K, M, P, and R with their respective holes in the circuit board.
- (✓) Lower the subpanel and switches until the switch lugs pass through the circuit board and the bushings of switches L and N pass through the subpanel. Temporarily secure switches L and N to the subpanel with control nuts. Do not solder the switches to the circuit board foil.
- (✓) Place a large rubber band around the subpanel and circuit board to hold the assembly together until the switch lugs are soldered in a later step.



PICTORIAL 11



PICTORIAL 9

Refer to Pictorial 9 for the following steps.

- (✓) Connect the lead from the marked end of a .01  $\mu$ fd tubular capacitor to R1-9 (S-1); be sure to push the lead through both lugs at R1-9, and then solder both lugs.
- (✓) Connect the other lead of this capacitor to P2-8 (NS). Position the capacitor so that neither of its leads touch other switch parts.
- (✓) Refer to Detail 9A and prepare a 1 M $\Omega$  precision resistor and a 1000 pf mica capacitor combination.



Detail 9A

- (✓) Connect this resistor-capacitor combination from P2-11 (S-1) to K2-5 (S-3).

- (✓) Prepare the following lengths of wire:

2-1/2"	4-1/4"	2"
3-3/4"	2-1/2"	1-3/4"
3-3/4"	2-1/2"	3-3/4"
2"		

- (✓) Connect a 2-1/2" wire from P2-10 (S-1) to K1-6 (S-1).
- (✓) Connect a 3-3/4" wire from P2-8 (S-2) to K1-8 (S-3).
- (✓) Carefully spread apart the front and rear lugs 8 of switch M.
- (✓) Connect a 3-3/4" wire from P2-3 (S-1) to lug 8 on the front of the wafer on switch M (NS).
- (✓) Connect a 2" wire from lug 8 on the front of the wafer on switch M (S-2) to R2-12 (S-1).
- (✓) Connect a 4-1/4" wire from lug 8 on the rear of the wafer on switch M (S-1) to P1-1 (S-1).
- (✓) Connect a 2-1/2" wire between P1-3 (S-1) and P3-3 (NS).
- (✓) Connect one end of a 2-1/2" wire to P3-3 (S-2). Leave the other end free, as it will be connected later.

- (✓) Connect a 2" wire between P3-5 (NS) and P3-9 (S-1).
- (✓) Connect a 1-3/4" wire from P1-5 (S-1) to R1-8 (S-1).
- (✓) Connect a 3-3/4" wire from P1-6 (S-1) to lug 2 of phone jack T (S-1).
- (✓) Connect one end of a 2-1/2" black test lead wire to both lugs on M1-7 and solder both lugs. The other end will be connected later.
- (✓) Prepare the following lengths of wire:

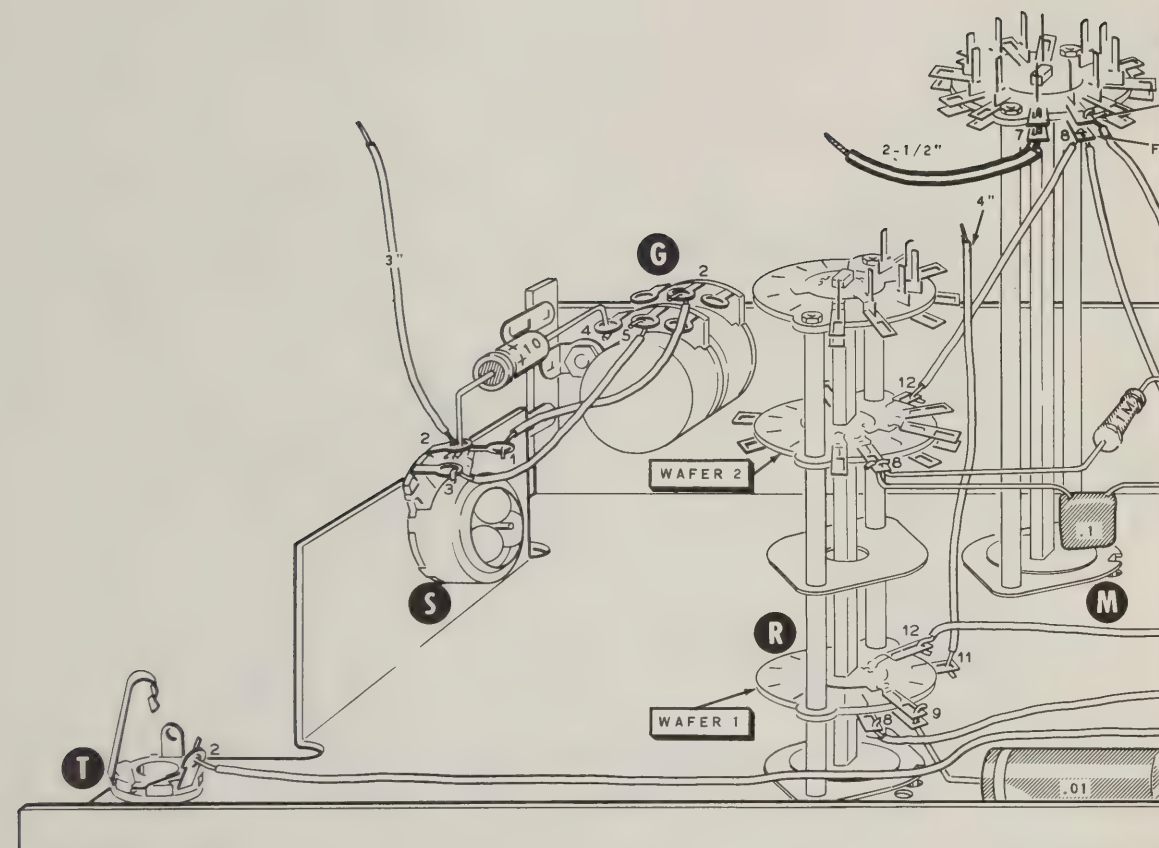
4"	3"	2-3/4"
2"	1-1/2"	2-1/4"
2-1/4"	2-1/4"	3-1/2"
2-1/2"	1-1/4"	

- (✓) Connect one end of a 4" wire to R1-11 (S-1). Leave the other end free, as it will be connected later.
- (✓) Connect a 2" wire from P2-4 (S-1) to R1-12 (S-1).
- (✓) Connect a .1  $\mu$ fd Mylar capacitor from P3-5 (NS) to R2-8 (NS).
- (✓) Connect a 1 M $\Omega$  precision resistor from R2-8 (NS) to P3-1 (S-1).
- (✓) Connect a 2-1/4" wire from lug 2 of control G (S-1) to lug 1 of control S (S-1).
- (✓) Connect a 2-1/2" wire from lug 5 of control G (S-1) to lug 3 of control S (S-1).
- (✓) Connect the positive (+) lead of a 10  $\mu$ fd electrolytic capacitor to lug 2 of control S (NS). Connect the other lead of this capacitor to lug 4 of control G (NS).
- (✓) Connect one end of a 3" wire to lug 2 of control S (S-2). Leave the other end free, as it will be connected later.

Refer to Pictorial 10 (fold-out from Page 17) for the following steps.

- (✓) Connect a 1-1/2" wire from R2-11 (S-1) to P3-2 (S-1).
- (✓) Connect one end of a 2-1/4" wire to R2-10. Be sure to place this wire through both lugs at R2-10 and then solder both lugs. Connect the other end of this wire to P3-6 (NS).





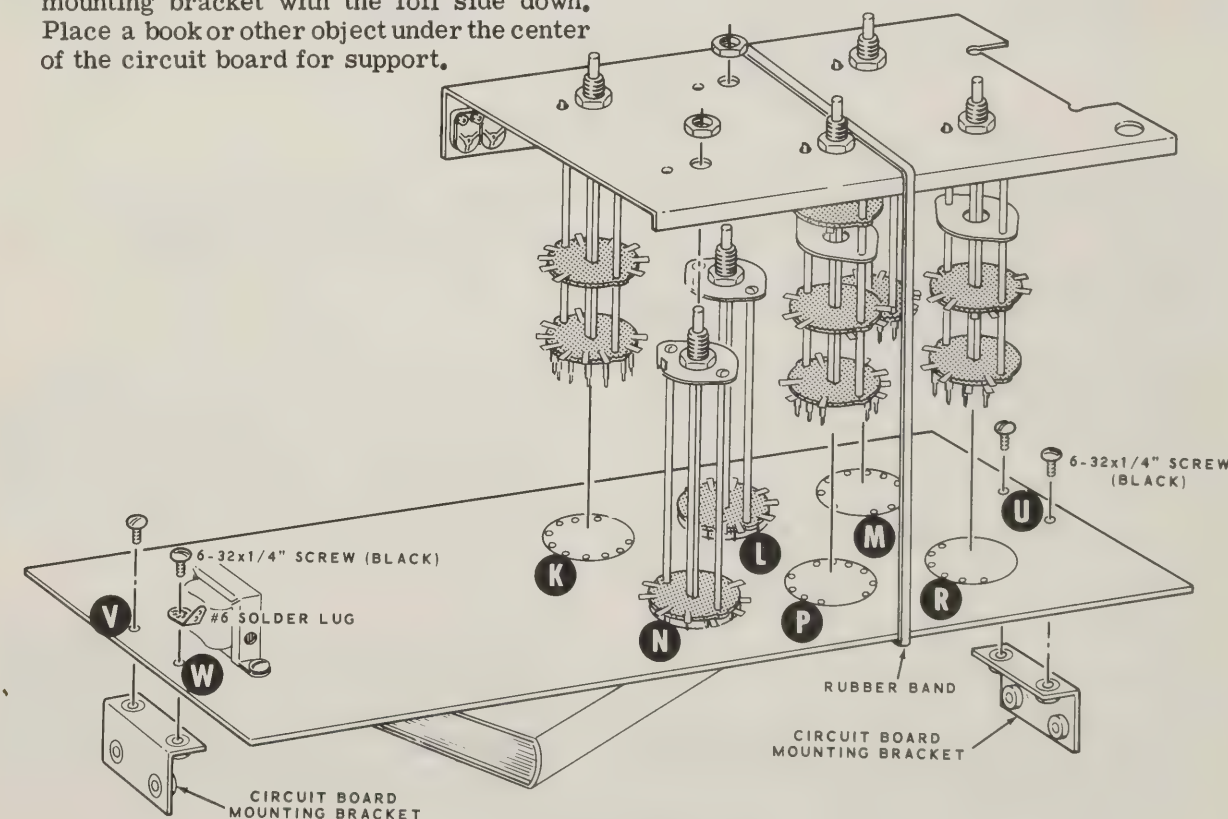
PICTORIAL

- (✓) Connect a 1-1/4" wire from R2-9 (S-1) to P3-4 (S-1).
- (✓) Connect a 2-3/4" wire from R2-7 (S-1) to P3-7 (S-1).
- (✓) Connect a 2-1/4" wire from P3-12 (S-1) to K2-6 (S-1).
- (✓) Connect a 3-1/2" wire from P3-10 (S-1) to K2-9 (S-3).

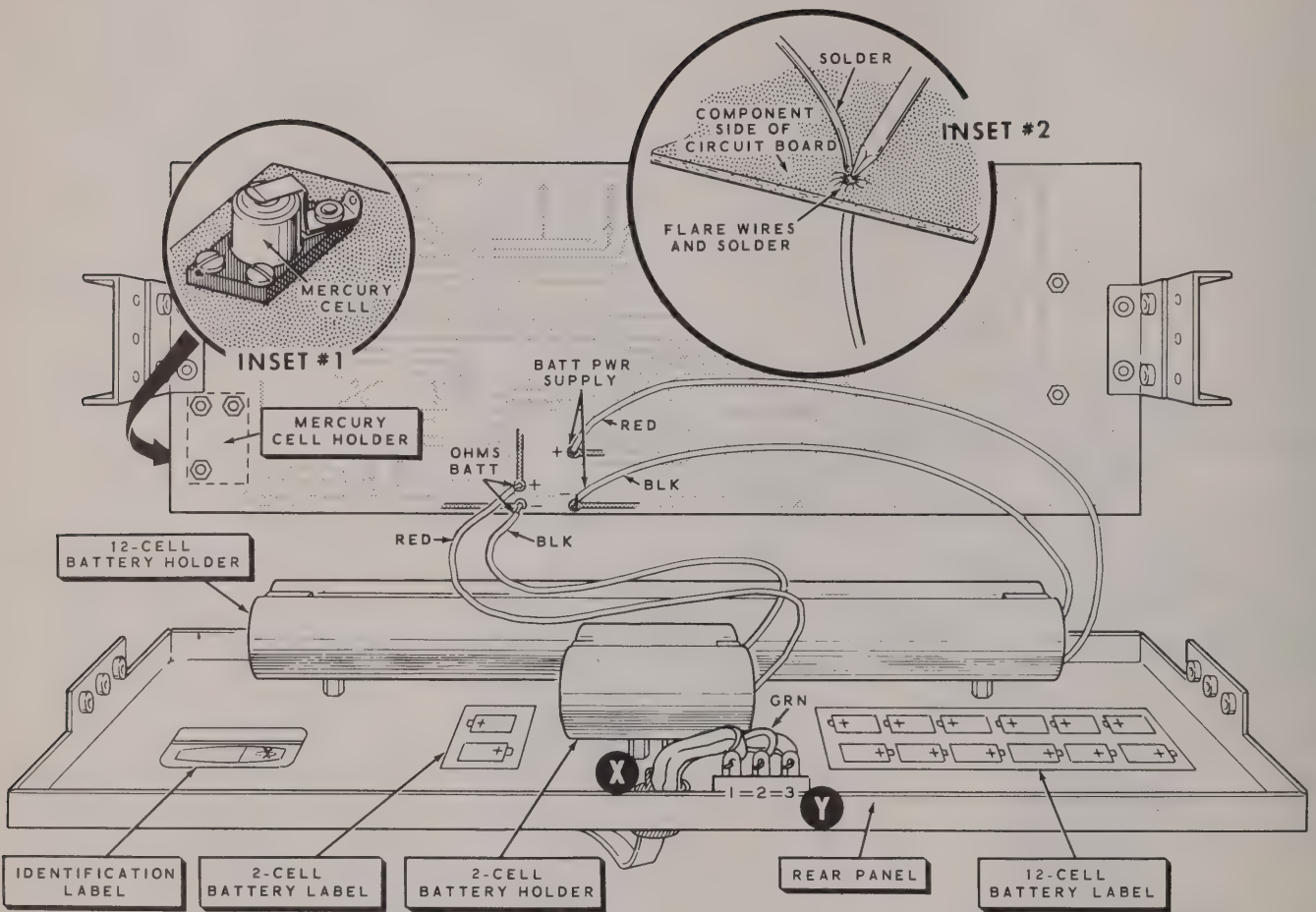
Refer to Pictorial 11 for the following steps.

- (✓) Position the circuit board as shown in Pictorial 11.
- (✓) Mount a circuit board mounting bracket at U on the foil side of the circuit board. Use two 6-32 x 1/4" black screws.
- (✓) Mount a circuit board mounting bracket at V on the foil side of the circuit board and a #6 solder lug at W on the component side of the board. Use two 6-32 x 1/4" black screws.
- (✓) Set the circuit board on the circuit board mounting bracket with the foil side down. Place a book or other object under the center of the circuit board for support.

- (✓) Mount the On-Off Power switch (#63-433) on the circuit board at N by inserting the lugs through the holes on the circuit board. Do not solder at this time.
- (✓) Similarly, mount the Ohms Range switch (#63-434) on the circuit board at L. Do not solder at this time.
- (✓) Place the subpanel above the circuit board and line up the switch lugs on switches K, M, P, and R with their respective holes in the circuit board.
- (✓) Lower the subpanel and switches until the switch lugs pass through the circuit board and the bushings of switches L and N pass through the subpanel. Temporarily secure switches L and N to the subpanel with control nuts. Do not solder the switches to the circuit board foil.
- (✓) Place a large rubber band around the subpanel and circuit board to hold the assembly together until the switch lugs are soldered in a later step.



PICTORIAL 11



PICTORIAL 17





- (✓) Form a hook in the free end of the black test lead wire extending from M1-7. Connect and solder this wire to the end of the .1  $\Omega$  precision resistor as shown in Pictorial 12. Use only enough heat to solder the connection.
- (✓) Connect and solder one end of a 4-1/4" black test lead wire to the other end of the .1  $\Omega$  precision resistor. Connect the other end of this wire to lug 1 of phone jack T (S-1).
- (✓) Connect a 3" wire from R2-4 (S-1) to P3-5 (S-3).
- (✓) Connect a 2" wire from R2-1 (S-1) to the hole in the circuit board labeled "AC-DC switch, lug 1, wafer 2" (S-1).
- (✓) Connect the free end of the wire extending from lug 2 of control S to the hole in the circuit board labeled "Zero control, lug 2" (S-1).

Refer to Pictorial 13 (fold-out from Page 18) for the following steps.

- (✓) Mount a 2000  $\Omega$  control (#10-52) at D. Secure the control by twisting the mounting tabs 1/8 turn.
- (✓) Mount a 10 K $\Omega$  control (#10-57) at E. Secure the control by twisting the mounting tabs 1/8 turn.
- (✓) Mount a 10 K $\Omega$  control (#10-57) at F. Secure the control by twisting the mounting tabs 1/8 turn.

Connect the wires from breakout #1 of the cable assembly as follows:

- (✓) Either blue to lug 1 of terminal strip H (NS).
- (✓) Other blue to lug 2 of terminal strip H (NS).
- (✓) Black to lug 4 of control G (S-2).
- (✓) Red to lug 3 of control G (S-1).

Connect the wires from breakout #2 of the cable assembly as follows:

- (✓) White-red to lug 2 of control F (S-1).
- (✓) Gray to lug 3 of control F (S-1).

Connect the wires from breakout #4 as follows:

- (✓) Either orange to lug 2 of control E (S-1).
- (✓) Other orange to lug 3 of control E (S-1).

Connect the wires from breakout #5 as follows:

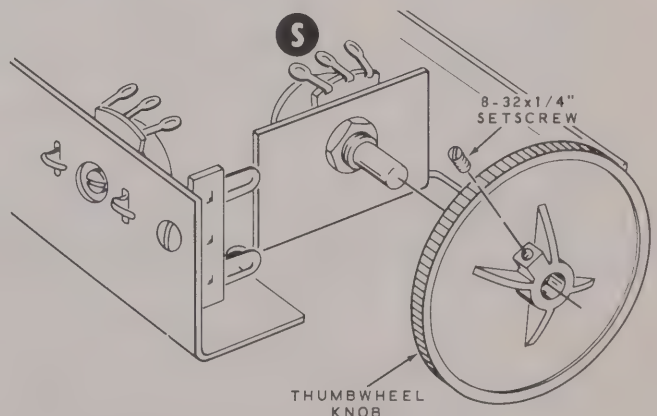
- (✓) Both white-red to lug 2 of control D (S-2).
- (✓) Brown to lug 3 of control D (S-1).

Connect the wires from breakout #6 as follows:

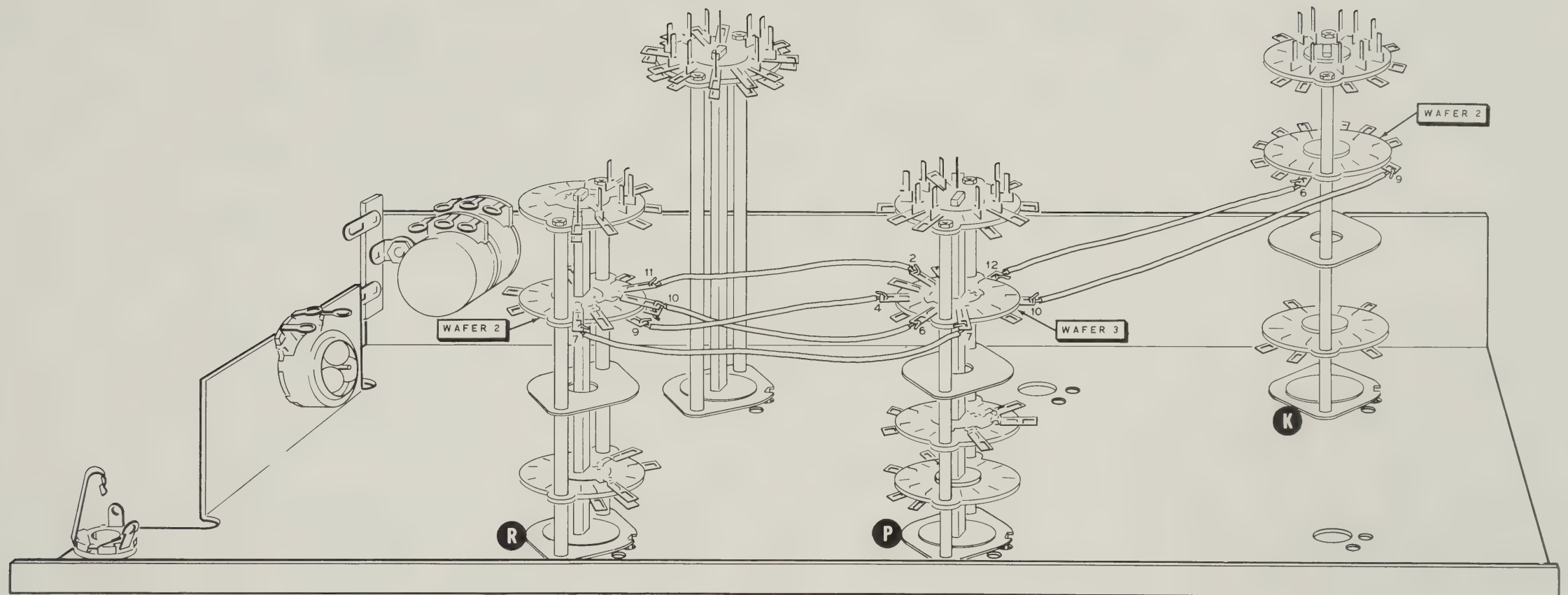
- (✓) Both black wires to lug 1 of control C (S-5).

Connect the wires from breakout #7 as follows:

- (✓) Violet to lug 3 of control C (S-1).
- (✓) Green to K2-4 (S-3).
- (✓) Strip 1" of insulation from a piece of hookup wire. Then place this insulation on one lead of an NE-2H neon lamp.
- (✓) Connect the insulated lead of the neon lamp to lug 1 (S-2) and the other lead to lug 2 (S-2) of terminal strip H. Position the body of the lamp halfway through the hole in the subpanel.
- (✓) Start an 8-32 x 1/4" setscrew in the thumb-wheel knob as shown in Detail 13A. Install this knob all the way on the shaft of control S and tighten the setscrew. Be sure this knob turns freely and does not rub on the black stranded wire connected to the phone jack.

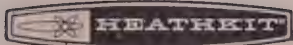


Detail 13A



PICTORIAL 10





- (✓) Form a hook in the free end of the black test lead wire extending from M1-7. Connect and solder this wire to the end of the .1  $\Omega$  precision resistor as shown in Pictorial 12. Use only enough heat to solder the connection.
- (✓) Connect and solder one end of a 4-1/4" black test lead wire to the other end of the .1  $\Omega$  precision resistor. Connect the other end of this wire to lug 1 of phone jack T (S-1).
- (✓) Connect a 3" wire from R2-4 (S-1) to P3-5 (S-3).
- (✓) Connect a 2" wire from R2-1 (S-1) to the hole in the circuit board labeled "AC-DC switch, lug 1, wafer 2" (S-1).
- (✓) Connect the free end of the wire extending from lug 2 of control S to the hole in the circuit board labeled "Zero control, lug 2" (S-1).

Refer to Pictorial 13 (fold-out from Page 18) for the following steps.

- (✓) Mount a 2000  $\Omega$  control (#10-52) at D. Secure the control by twisting the mounting tabs 1/8 turn.
- (✓) Mount a 10 K $\Omega$  control (#10-57) at E. Secure the control by twisting the mounting tabs 1/8 turn.
- (✓) Mount a 10 K $\Omega$  control (#10-57) at F. Secure the control by twisting the mounting tabs 1/8 turn.

Connect the wires from breakout #1 of the cable assembly as follows:

- (✓) Either blue to lug 1 of terminal strip H (NS).
- (✓) Other blue to lug 2 of terminal strip H (NS).
- (✓) Black to lug 4 of control G (S-2).
- (✓) Red to lug 3 of control G (S-1).

Connect the wires from breakout #2 of the cable assembly as follows:

- (✓) White-red to lug 2 of control F (S-1).
- (✓) Gray to lug 3 of control F (S-1).

Connect the wires from breakout #4 as follows:

- (✓) Either orange to lug 2 of control E (S-1).
- (✓) Other orange to lug 3 of control E (S-1).

Connect the wires from breakout #5 as follows:

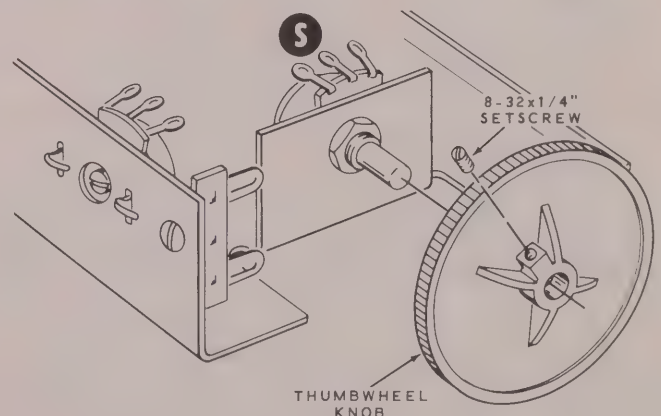
- (✓) Both white-red to lug 2 of control D (S-2).
- (✓) Brown to lug 3 of control D (S-1).

Connect the wires from breakout #6 as follows:

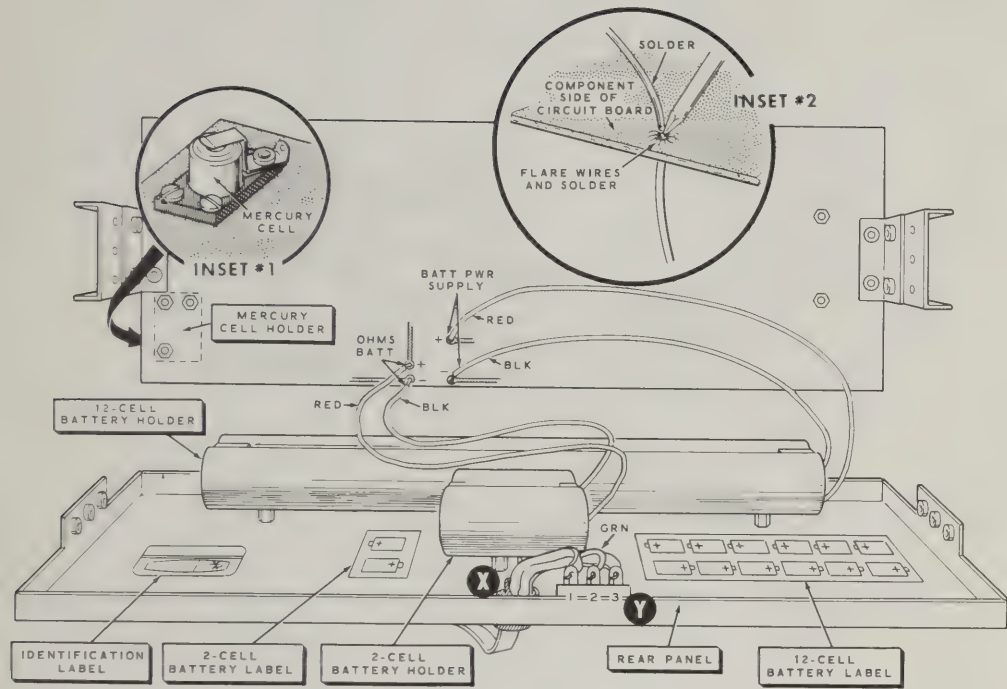
- (✓) Both black wires to lug 1 of control C (S-5).

Connect the wires from breakout #7 as follows:

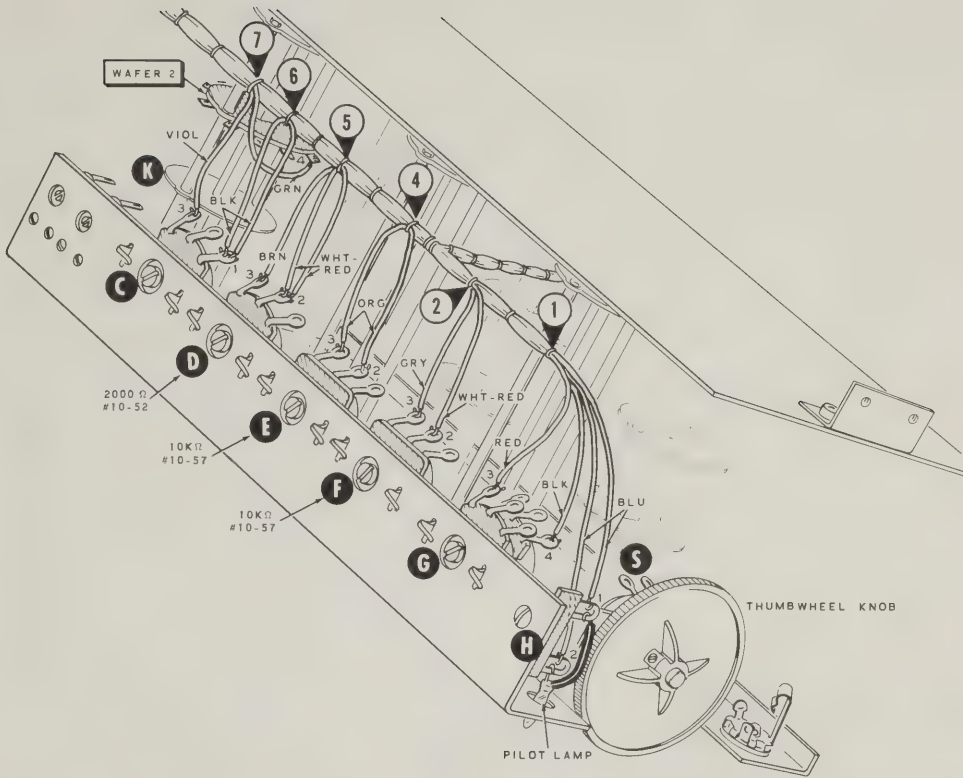
- (✓) Violet to lug 3 of control C (S-1).
- (✓) Green to K2-4 (S-3).
- (✓) Strip 1" of insulation from a piece of hookup wire. Then place this insulation on one lead of an NE-2H neon lamp.
- (✓) Connect the insulated lead of the neon lamp to lug 1 (S-2) and the other lead to lug 2 (S-2) of terminal strip H. Position the body of the lamp halfway through the hole in the subpanel.
- (✓) Start an 8-32 x 1/4" setscrew in the thumbwheel knob as shown in Detail 13A. Install this knob all the way on the shaft of control S and tighten the setscrew. Be sure this knob turns freely and does not rub on the black stranded wire connected to the phone jack.



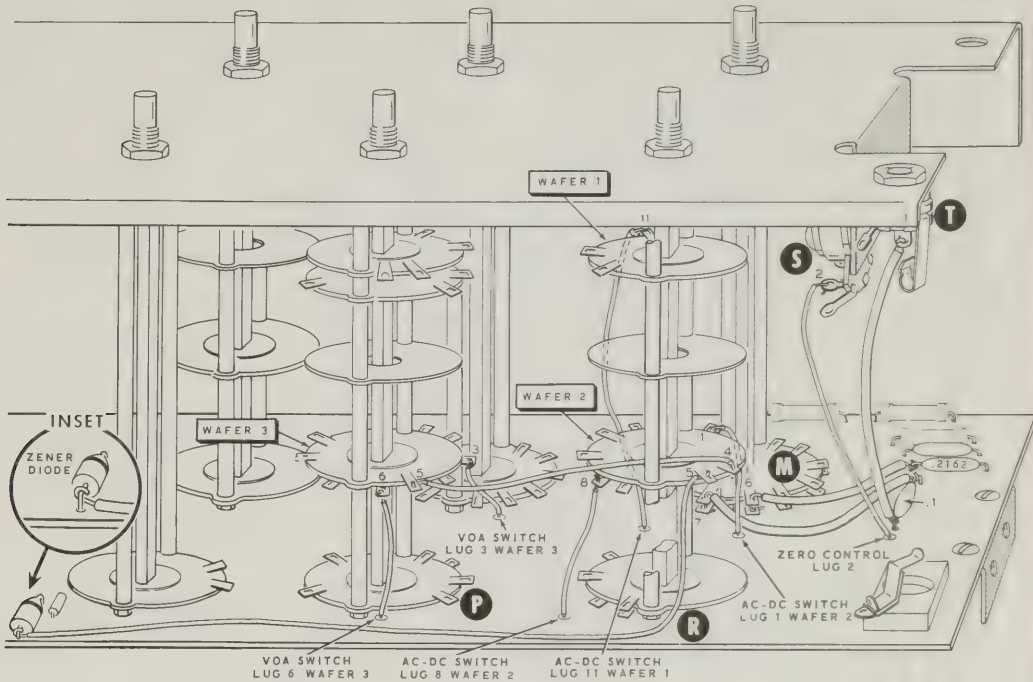
Detail 13A



PICTORIAL 17



PICTORIAL 13



PICTORIAL 12

Refer to Pictorial 12 for the following steps.

- (✓) Connect the free end of the wire extending from P3-3 to the hole in the circuit board labeled "VOA switch, lug 3, wafer 3" (S-1).
- (✓) Connect the free end of the wire extending from R1-11 to the hole in the circuit board labeled "AC-DC switch, lug 11, wafer 1" (S-1).

Prepare the following lengths of wire:

1-3/4"	4-1/4" black test lead
1-3/4"	3"
8"	2"
2" black test lead	

- (✓) Connect a 1-3/4" wire from P3-6 (S-2) to the hole in the circuit board labeled "VOA switch, lug 6, wafer 3" (S-1).

- (✓) Connect a 1-3/4" wire from R2-8 (S-3) to the hole in the circuit board labeled "AC-DC switch, lug 8, wafer 2" (S-1).
- (X) Connect one end of an 8" wire to R2-5 (S-1). Form a hook in the other end of this wire and connect it to the lead of the zener diode on the circuit board as shown in the inset drawing. Use only enough heat to solder the connection.
- (✓) Place one end of a 2" black test lead wire through both lugs at M1-6 and solder both lugs. Form a hook in the other end of this wire and connect it to the lead of the .2162  $\Omega$  precision resistor on the circuit board as shown in Pictorial 12. Use only enough heat to solder the connection.





(4) Place one end of a 2" black test lead wire through both lugs at M1-6 and solder both lugs. Form a hook in the other end of this wire and connect it to the lead of the .2162  $\Omega$  precision resistor on the circuit board as shown in Pictorial 12. Use only enough heat to solder the connection.

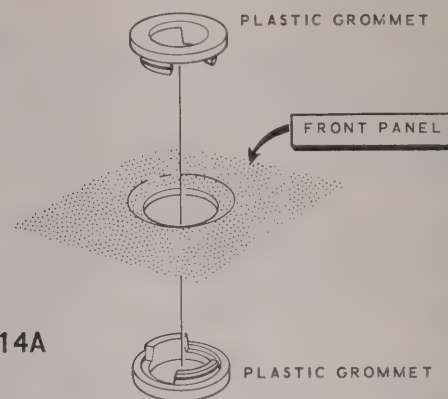
- ( ) Grav to lug 3 of control F (S-1).

( ) Start an 8-32 x 1/4" setscrew in the thumb-wheel knob as shown in Detail 13A. Install this knob all the way on the shaft of control S and tighten the setscrew. Be sure this knob turns freely and does not rub on the black stranded wire connected to the phone jack.



Refer to Pictorial 14 for the following steps.

- (✓) Connect the free lead of the .005  $\mu$ fd disc capacitor near the transformer to solder lug W (S-1).
- (✓) Mount a side rail on circuit board mounting bracket V. Use two 6-32 x 1/4" black screws.
- (✓) Similarly, mount a side rail on circuit board mounting bracket U.
- (✓) Locate the front panel and mount the pilot lamp lens at J with a speednut.
- (✓) Install plastic grommets at locations K, L, M, N, P, and R. See Detail 14A.
- (✓) Remove the control nuts from the bushings of all six switches.
- (✓) Place a control flat washer over the bushing of each of the six switches.
- (✓) Position the front panel on the switch bushings but do not secure the switches at this time. Be sure the neon pilot lamp slips into the pilot lamp lens at J.
- (✓) Slide the bezel over the front panel and into position.
- (✓) Secure the front panel and bezel to the side rails with two 6-32 x 1/2" screws and a 6-32 x 7/16" spacer stud on each side.

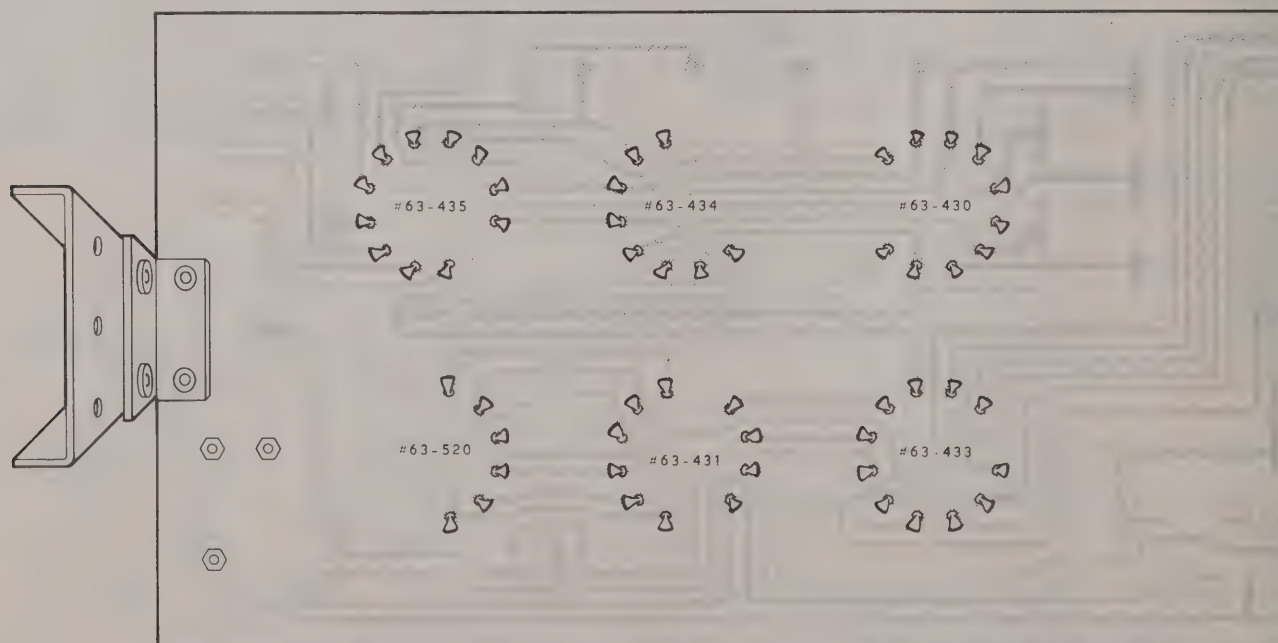


Detail 14A

- (✓) Secure the front panel to switches K, L, M, N, P, and R with a control flat washer and control nut on each switch bushing.

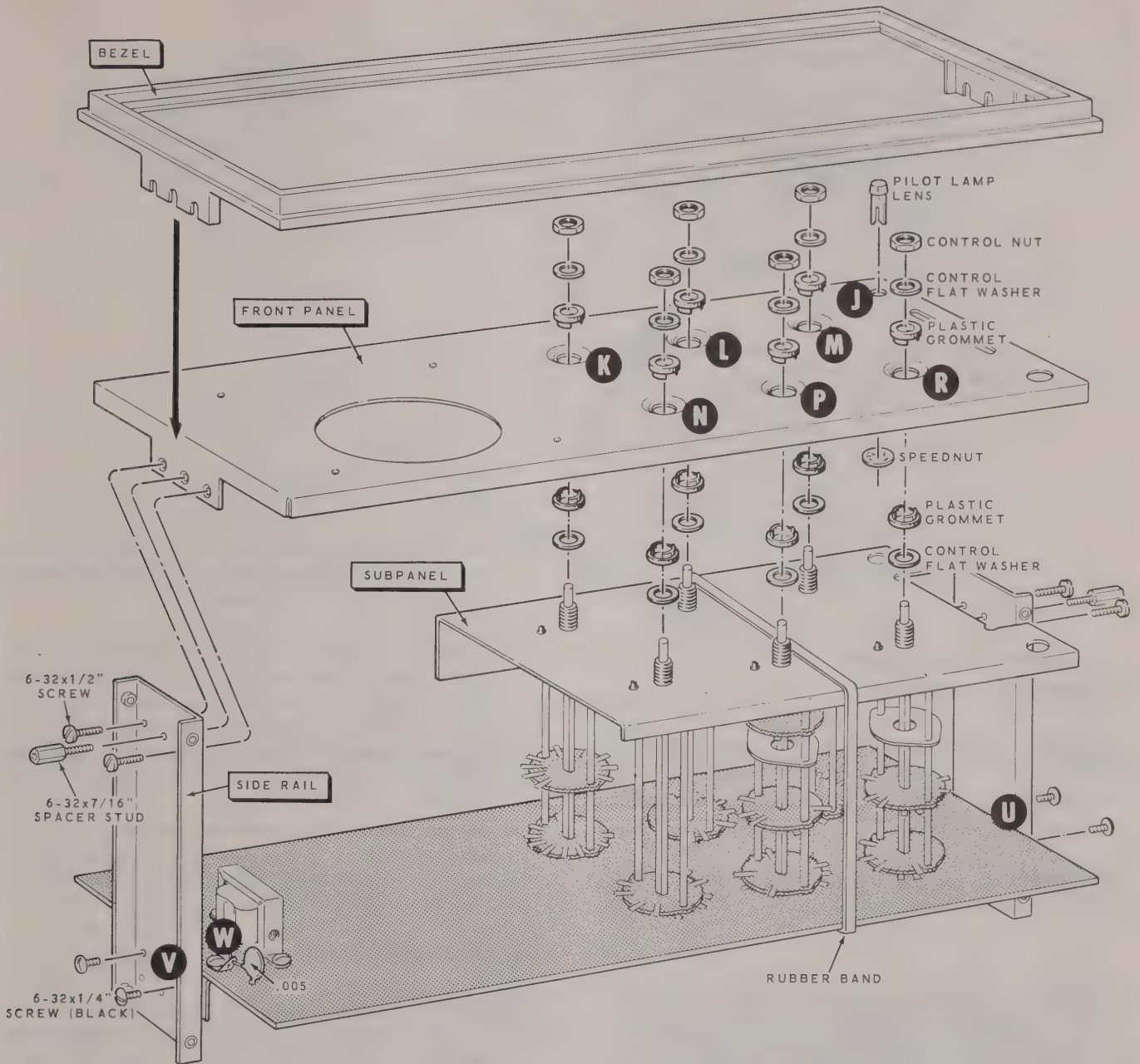
Refer to Pictorial 15 for the following steps.

- (✓) Turn the unit upside down so that it sits on the switch shafts.
- (✓) Inspect the circuit board for bends or warped areas. Straighten the circuit board if necessary.
- (✓) Be sure all switch lugs protrude through the circuit board. Then solder the lugs on all six switches to the circuit board foil.
- (✓) Cut the rubber band that was used to hold the assembly together. Remove it from the assembly.

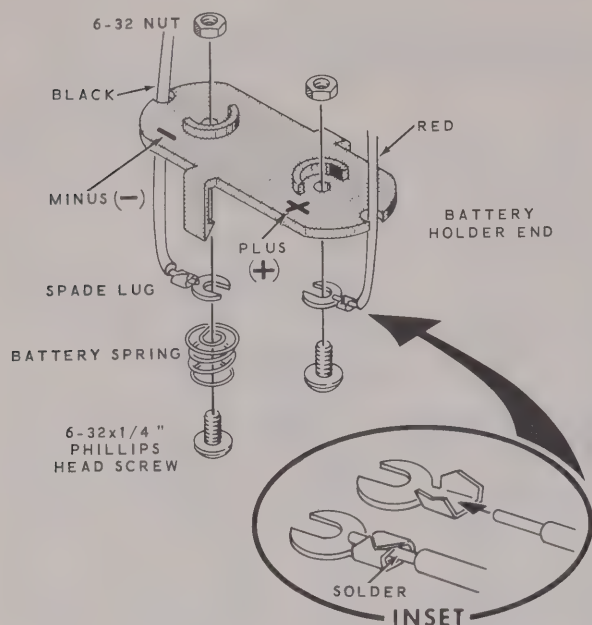


PICTORIAL 15





PICTORIAL 14

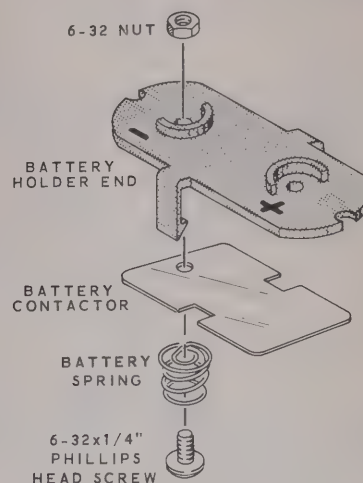


Detail 16A

### BATTERY HOLDER AND REAR PANEL ASSEMBLY

Refer to Detail 16A for the following steps.

- (✓) Cut two 12" lengths of black stranded and two 12" lengths of red stranded wire.
- (✓) Refer to the inset drawing on Detail 16A and install a spade lug on one end of each wire.
- (✓) Mount a battery spring and the spade lug end of a black stranded wire in the minus (-) hole in a battery holder end. Use a 6-32 x 1/4" phillips head screw, and a 6-32 nut.
- (✓) Mount the spade lug end of a red stranded wire in the positive (+) hole in the same battery holder end. Use a 6-32 x 1/4" phillips head screw, and a 6-32 nut.



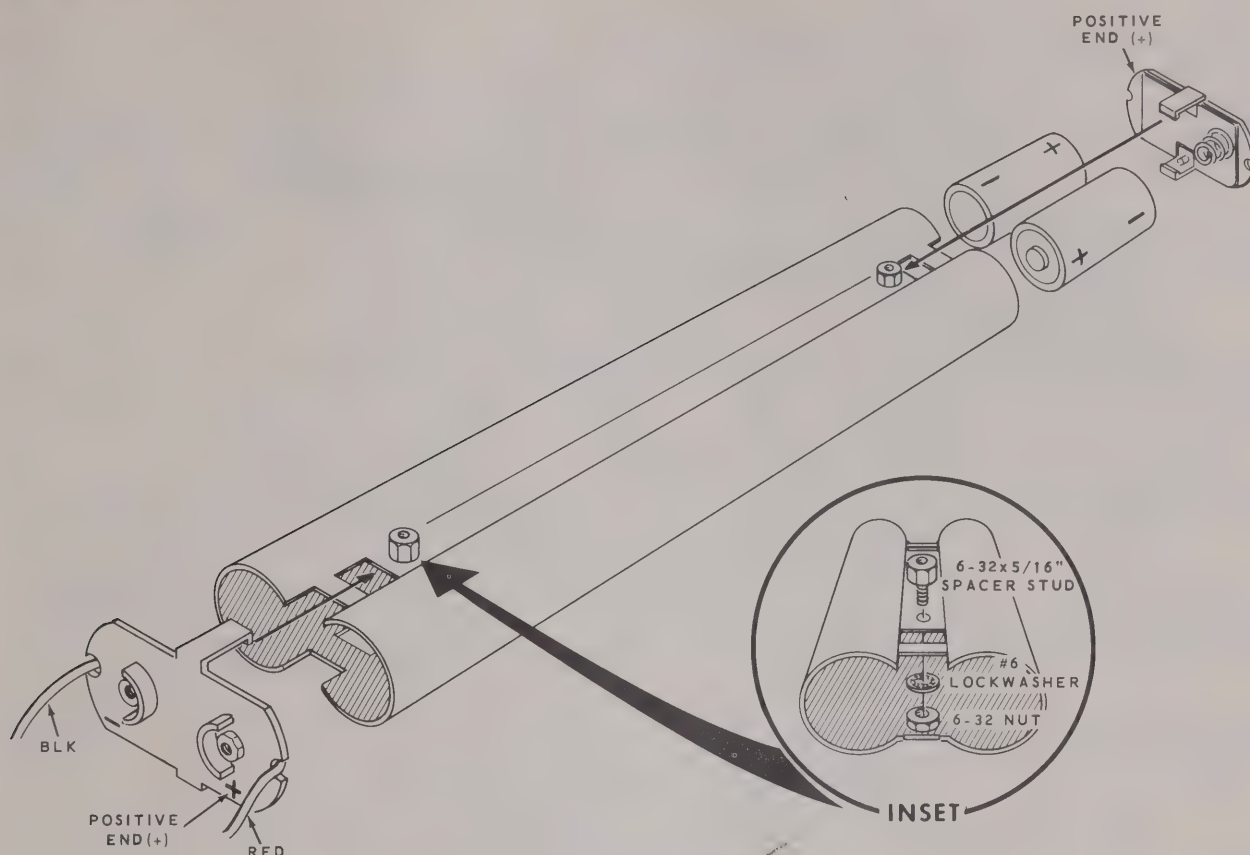
Detail 16B

- (✓) Bend the red and black stranded wires back at a 90 degree angle so they fit into the slots in the battery holder end.
- (✓) Locate another battery holder end and install a battery spring and the spade lug end of the remaining black stranded wire. Use a 6-32 x 1/4" phillips head screw, and a 6-32 nut in the minus (-) hole in the battery holder end.
- (✓) Mount the spade lug end of the remaining red stranded wire to the positive (+) hole in the battery holder end. Use a 6-32 x 1/4" phillips head screw, and a 6-32 nut.

Refer to Detail 16B for the following steps.

- (✓) Place a battery contactor in the battery holder end. Secure the battery contactor with a battery spring, a 6-32 x 1/4" phillips head screw, and a 6-32 nut in the minus (-) hole.
- (✓) Similarly, install another battery contactor in the remaining battery holder end. Use a battery spring, a 6-32 x 1/4" phillips head screw, and a 6-32 nut in the minus (-) hole.





Detail 16C

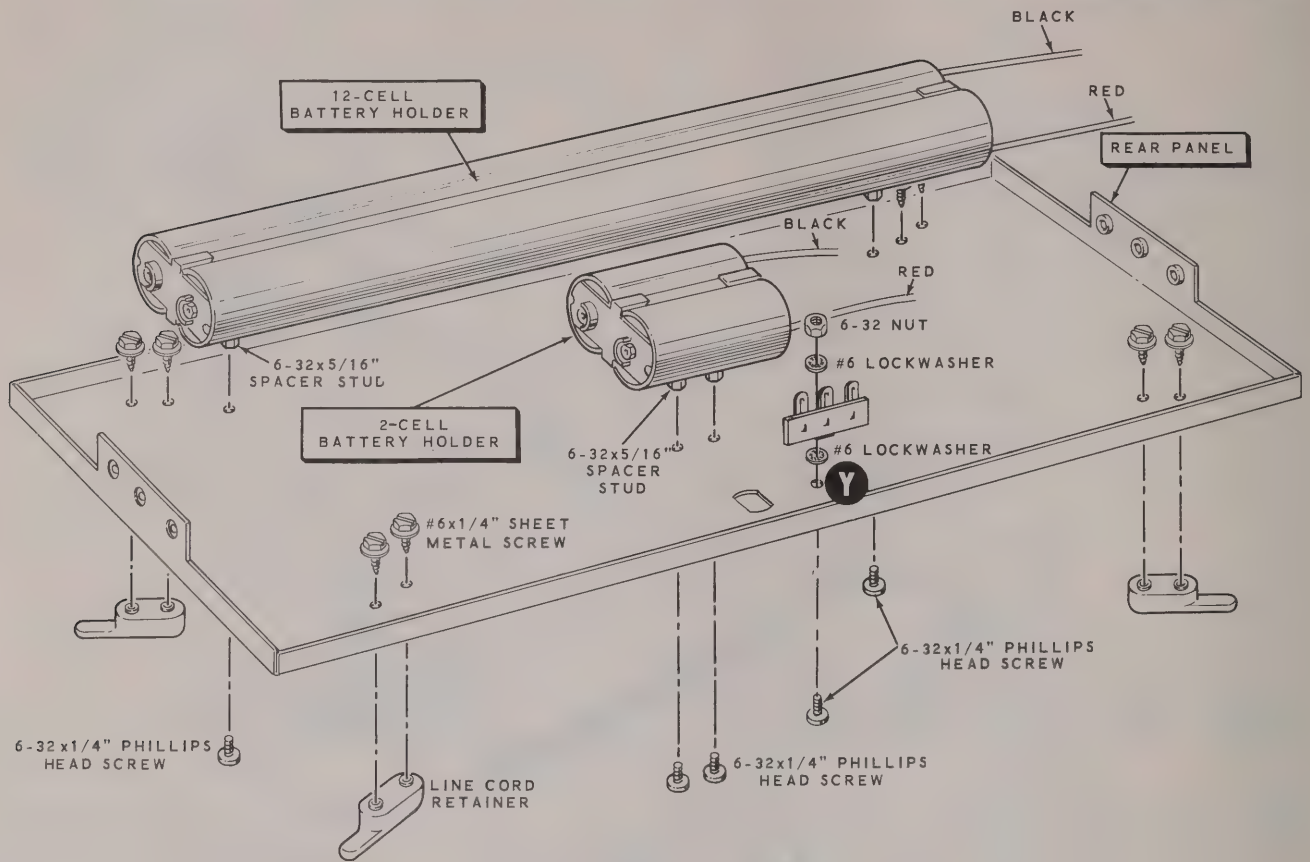
NOTE: The 2-cell, and the 12-cell, battery holders are identical except for their lengths. Refer to Detail 16C to assemble both battery holders.

- (✓) Mount a 6-32 x 5/16" spacer stud on each end of the 12-cell battery holder case. Use a #6 lockwasher and a 6-32 nut as shown in the inset drawing on Detail 16C.
- (✓) Similarly, install two 6-32 x 5/16" spacer studs on the 2-cell battery holder. Use #6 lockwashers and 6-32 nuts.
- (✓) Install one of the battery holder ends without wires on one end of the 12-cell battery holder. Position the positive (+) end of the battery holder end as shown.

CAUTION: After you install the batteries in their holders in the following steps, be careful that the leads do not short together.

- (✓) Insert twelve 1.5 volt C cells in the 12-cell battery holder. Position the positive (+) end of the cells as shown in Detail 16C.

- (✓) Install one of the battery holder ends with wires on the open end of the 12-cell battery holder. Position the positive (+) end of the battery holder end as shown.
- (✓) Position the 2-cell battery holder as shown in Detail 16C.
- (✓) Install the remaining battery holder end without wires on one end of the 2-cell battery holder. Position the positive (+) end of the battery holder end as shown in Detail 16C.
- (✓) Insert two 1.5 volt C cells in the 2-cell battery holder. Position the positive (+) end of the cells as shown.
- (✓) Install the remaining battery holder end with wires on the 2-cell battery holder. Position the positive (+) end of the battery holder end as shown in Detail 16C.



PICTORIAL 16

Refer to Pictorial 16 for the following steps.

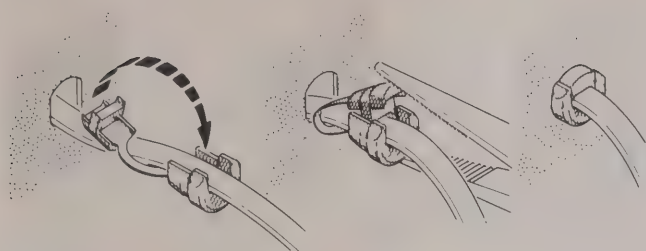
- (✓) Mount a line cord retainer in each corner of the rear panel. Use two #6 x 1/4" sheet metal screws to mount each retainer. Position the retainers as shown in Pictorial 16.
- (✓) To be sure the spacer studs line up with the holes in the panel, temporarily hold the 12-cell battery holder, and then the 2-cell battery holder, in position against the rear panel. If necessary, loosen and reposition the spacer studs; then retighten them.
- (✓) Mount the 12-cell battery holder on the rear panel with two 6-32 x 1/4" phillips head screws. Position the holder as shown.
- (✓) Mount the 2-cell battery holder on the rear panel with two 6-32 x 1/4" phillips head screws. Position the holder as shown.

- (✓) Mount a 3-lug terminal strip at Y. Use a 6-32 x 1/4" phillips head screw, two #6 lockwashers, and a 6-32 nut as shown.

Refer to Pictorial 17 (fold-out from Page 18) for the following steps.

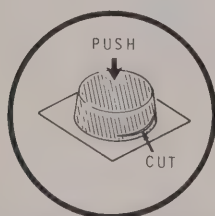
- (✓) Twist the stranded wires on each line cord lead, then melt a small amount of solder on the lead end to hold the wire strands together.
- (✓) Place the line cord through hole X and connect the green lead to lug 2 of terminal strip Y (S-1).
- (✓) Connect either of the other two line cord leads to lug 1 (NS) and the other to lug 3 (NS) of terminal strip Y.





Detail 17A

- (✓) Refer to Detail 17A and install the proper line cord strain relief in hole X. The strain relief shown is for the flat line cord supplied with the kit. If a round line cord is used, the other strain relief must be used.
- (✓) Wrap the line cord around the four line cord retainers.
- (✓) Turn all switch shafts to their full counterclockwise positions.
- (✓) Refer to Detail 17B and cut the silicone grease pod as shown. Apply a small amount of grease over the surface of each contact of the mercury cell holder.
- (✓) Apply a small amount of grease over each end of the mercury cell and install it in the cell holder. The positive, blunt end has a (+) marking. This end should be seated in the recess of the cell holder, as shown in inset drawing #1 of Pictorial 17.
- (✓) Position the chassis assembly face down in front of the rear panel as shown.

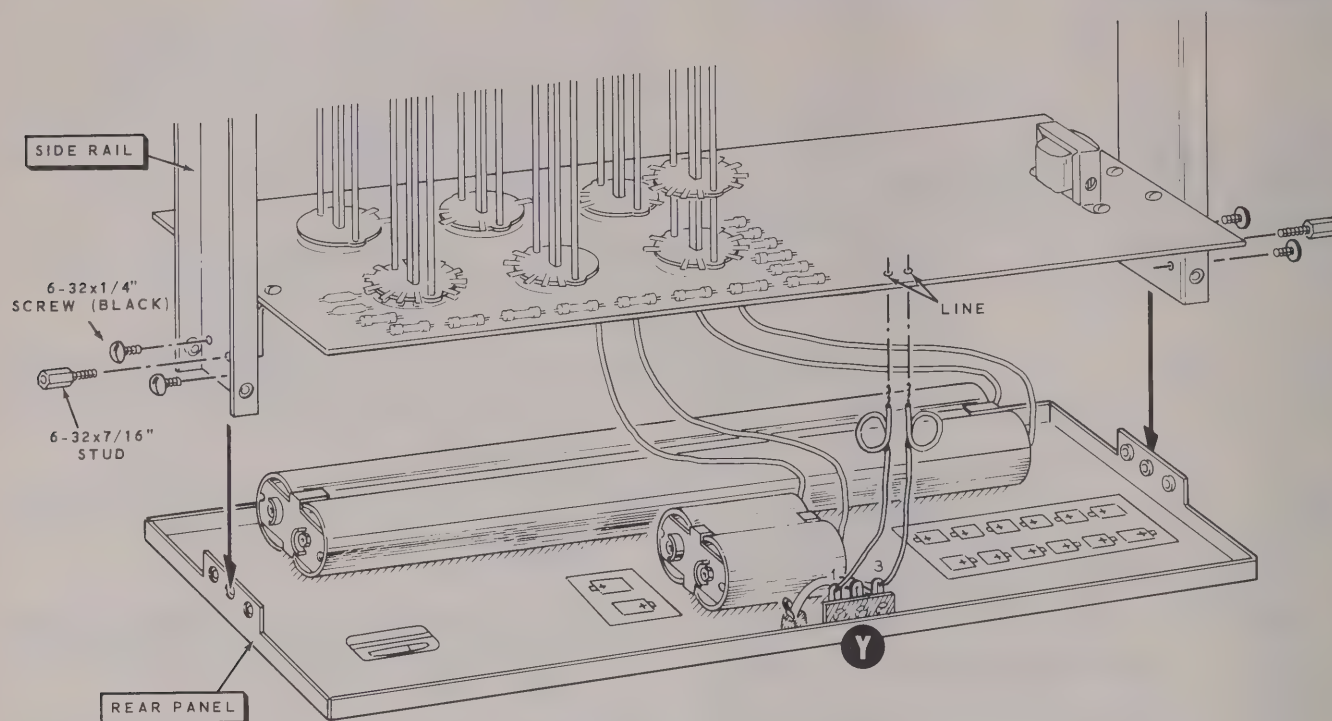


Detail 17B

NOTE: When you connect the battery holder leads in the next four steps, pass the end of each lead through its hole from the foil side of the circuit board. Then refer to inset drawing #2 on Pictorial 17 and flare and solder the end of each lead on the component side of the circuit board. Finally, solder each lead on the foil side of the board.

- (✓) Connect the red lead from the 2-cell battery holder to the hole in the circuit board labeled "Ohms Batt+" (S-1).
- (✓) Connect the black lead from the 2-cell battery holder to the hole in the circuit board labeled "Ohms Batt-" (S-1).
- (✓) Connect the red lead from the 12-cell battery holder to the hole in the circuit board labeled "Batt Pwr Supply +" (S-1).
- (✓) Connect the black lead from the 12-cell battery holder to the hole in the circuit board labeled "Batt Pwr Supply-" (S-1).
- (✓) Remove the backing paper from the 12-cell battery label and place the label on the rear panel as shown.
- (✓) Similarly, install the 2-cell battery label.
- (✓) Attach the blue and white identification label to the rear panel as shown.

NOTE: The blue and white identification label shows the Model number and Production Series number of your kit. Refer to these numbers in any communication with the Heath Company; this assures you of receiving the most complete and up-to-date information in return.



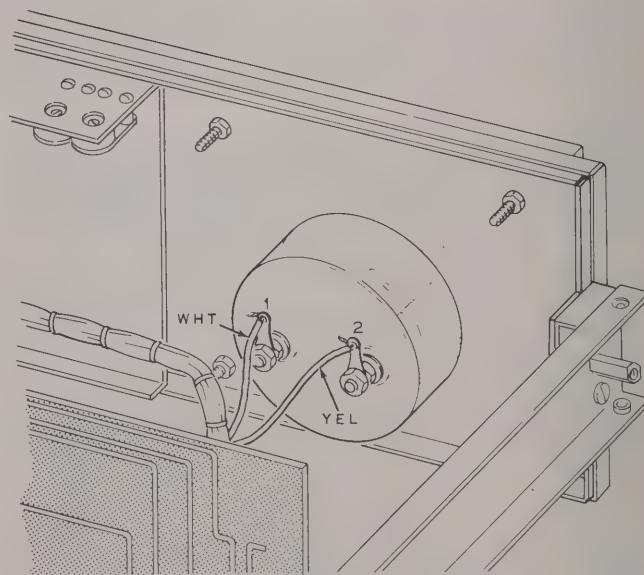
PICTORIAL 18

Refer to Pictorial 18 for the following steps.

- (✓) Slide the rear panel into position between the side rails. Secure both sides of the rear panel to the side rails with 6-32 x 1/4" black screws and 6-32 x 7/16" spacer studs.
- (✓) Connect a 4" wire from lug 1 of terminal strip Y (S-2) to one of the holes in the circuit board labeled "Line" (S-1). Make a loop in the wire to take up the slack.
- (✓) Connect a 4" wire from lug 3 of terminal strip Y (S-2) to the other hole in the circuit board labeled "Line" (S-1). Make a loop in the wire to take up the slack.

Refer to Pictorial 19 for the following steps.

- (✓) Carefully unpack the meter from its box and remove the shorting wire from between the meter terminals.
- (✓) Check to be sure the nuts are tight on the meter terminals. Tighten them, if necessary, by holding the inner nut with long-nose pliers or a thin open-end wrench while turning the outer nut.
- (✓) Mount the meter in the front panel. Use the lockwashers and nuts supplied with the meter. Do not overtighten the nuts.

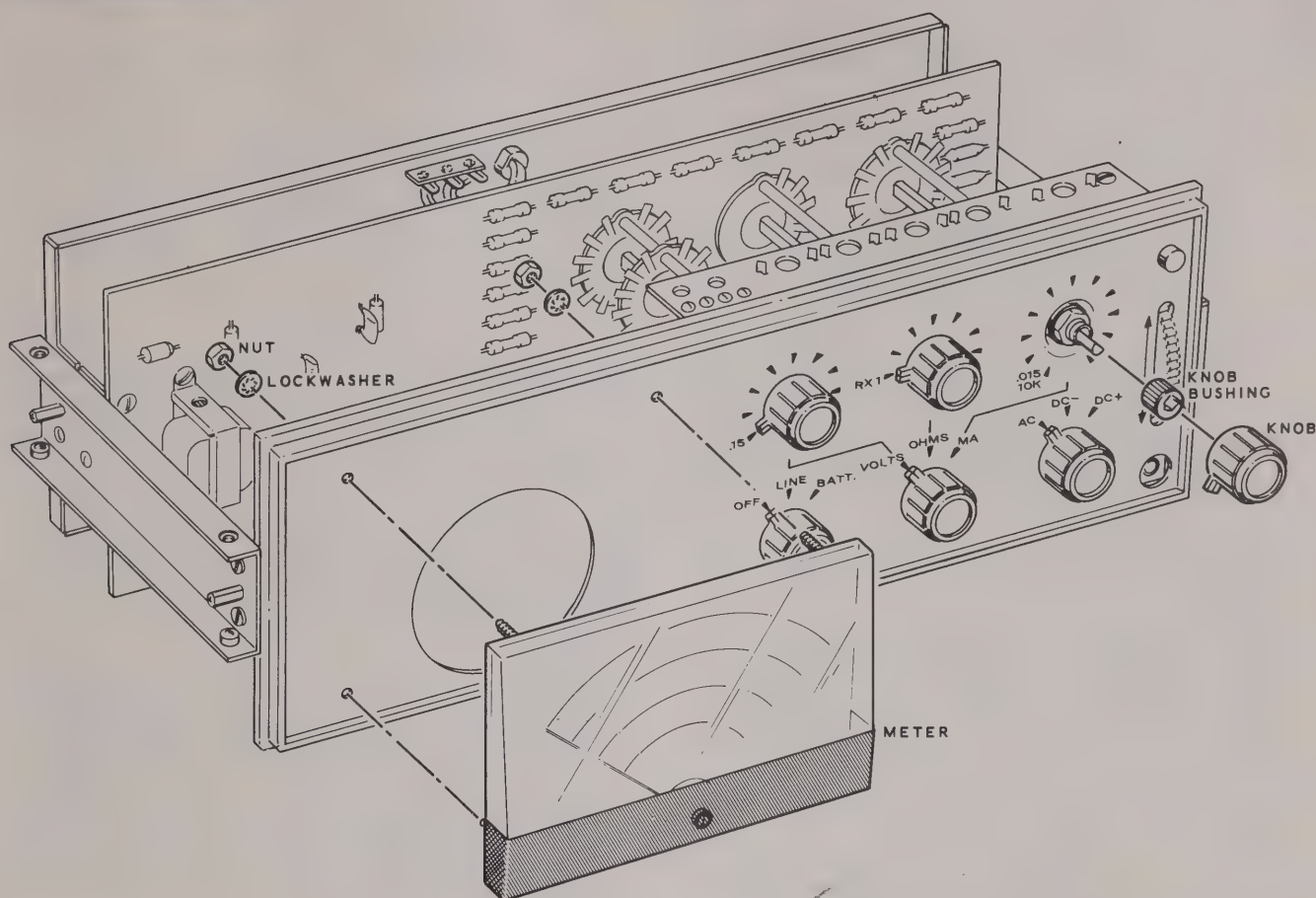


Detail 19A

- (✓) Refer to Detail 19A and connect the white cable assembly wire to lug 1 (S-1) and the yellow wire to lug 2 (S-1) of the meter.

This completes the wiring of the Solid State VOM. Inspect all connections to be sure they are soldered. Shake out any wire clippings or solder splashes. Proceed to the Knob Installation.





PICTORIAL 19

## KNOB INSTALLATION

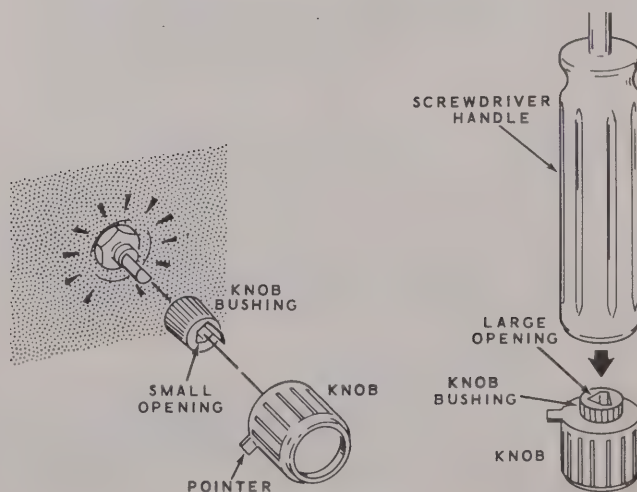
The knobs supplied with this kit use knob bushings that provide permanent positive gripping without the use of setscrews.

In the following steps you will install a knob on each of the six switch shafts as shown in Pictorial 19 and Detail 19B. Perform these steps carefully since it is very difficult to remove a knob bushing from a knob once it is fully inserted.

NOTE: Each knob will be made to align with particular switch markings. Whenever you remove a knob, be sure to replace it on the same switch shaft.

( ) Push a knob bushing part way onto each of the six switch shafts. Then turn all switch shafts to their full counterclockwise position.

- ( ) At one of the switch locations, line up the pointer of a knob with the full counterclockwise marking on the panel. Then press the knob slightly onto the knob bushing.
- ( ) Turn the knob clockwise to each of the switch stop positions. Check to see that the pointer lines up with each panel marking.



Detail 19B

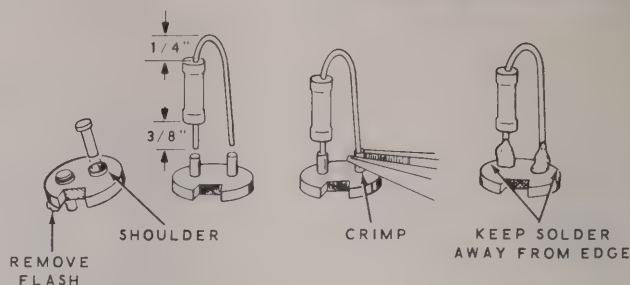
NOTE: Perform the next three steps only if the pointer does not line up at each switch marking.

1. (✓) Turn the knob pointer to the mid-position marking on the panel.
  2. (✓) Remove the knob from the bushing and turn it slightly to line up the pointer with the mid-position marking.
  3. (✓) Press the knob slightly onto the knob bushing. Then turn the knob to each switch position and recheck the pointer alignment. If more than a slight error is noticed at either end position, repeat these three steps.
- (✓) Carefully remove the knob bushing and knob together.
- (✓) Place the knob on a table or other hard surface, then press the knob bushing firmly into the knob. Use a towel or soft cloth on the work surface to avoid scratching the knob.
- (✓) Press the knob and bushing firmly onto the switch shaft.
- (✓) Repeat the above Knob Installation steps to install knobs on the remaining switch shafts. Then proceed to the Probe Assembly.

## PROBE ASSEMBLY

Refer to Pictorial 20 for the following steps.

- (✓) Locate the probe insert insulator. If necessary, remove any "flash" or sharp edge on the insert insulator with a file or penknife.
- (✓) Locate the two small rivets and the remaining 1 MΩ precision resistor shown in Detail 20A. Insert the rivets into the holes in the insulator so that the head of each rivet rests on the small shoulder around the hole in the insulator. Now turn the insulator over and lay it flat on the workbench.
- (✓) Cut one resistor lead to 3/8". Bend the other lead over and cut it flush with the first lead as shown in Detail 20A. Squeeze the leads together so that they line up with the rivet holes.

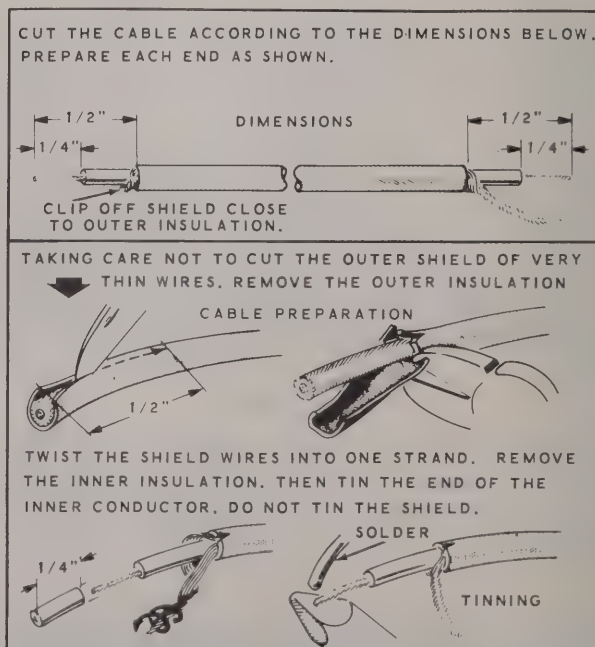


Detail 20A

- (✓) Insert the resistor leads into the rivets and lightly crimp the rivets with long-nose pliers or diagonal cutters to hold the resistor.

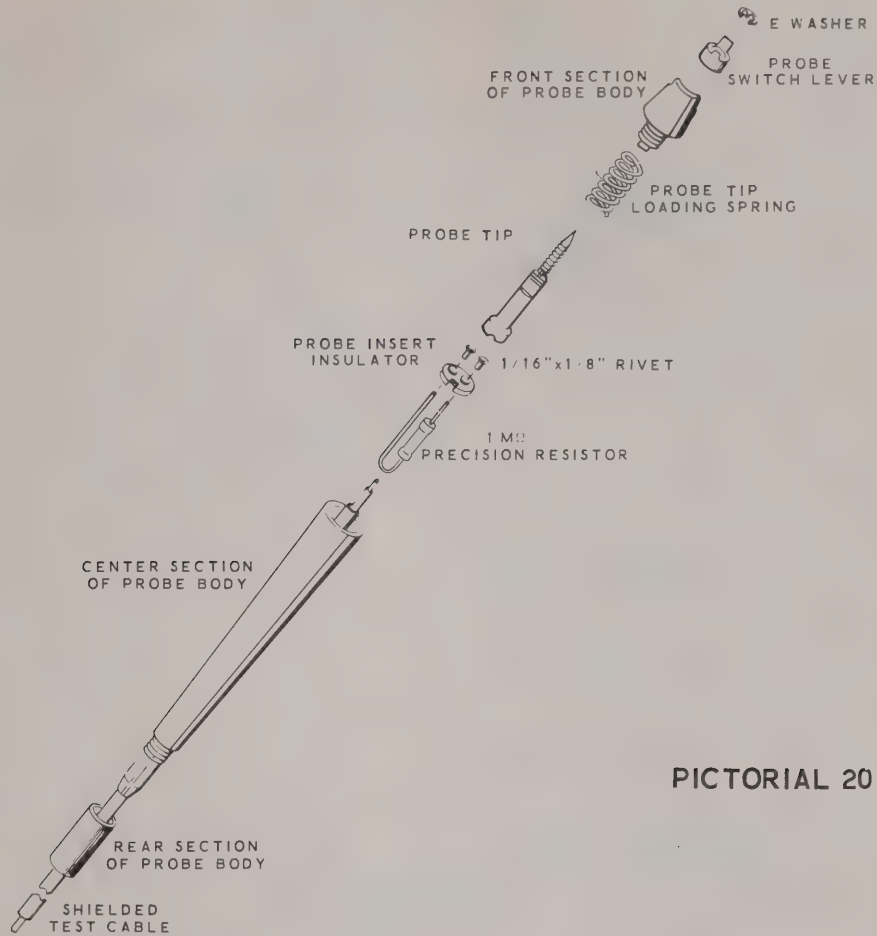
NOTE: Before proceeding further, check the position of the resistor on the insulator. With the notch in the insulator facing you, the resistor should be on the left-hand side.

- (✓) Solder the resistor leads to the rivets. Make sure the resistor is square with the insert insulator and that the solder flows down the rivet to hold the rivet tight against the shoulder. NOTE: Keep solder away from the edge of the insert insulator to provide clearance for the internal shoulder of the probe center section.
- (✓) Refer to Detail 20B and prepare the shielded cable as shown.



Detail 20B

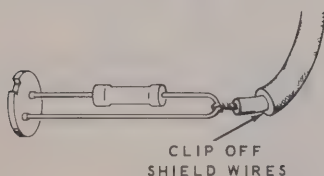




PICTORIAL 20

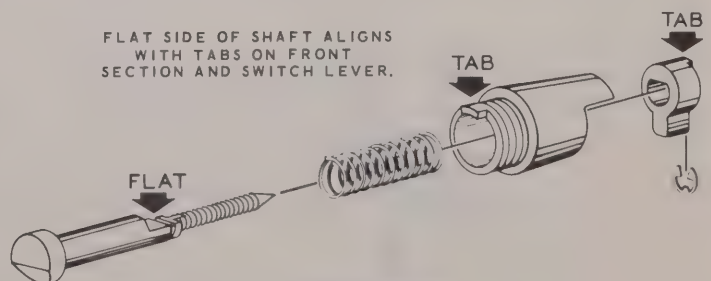
NOTE: In the following steps, take special care to avoid melting or cutting the inner plastic insulation of the shielded cable. When soldering, hold the wire with long-nose pliers near the insulation to conduct the heat away from the plastic insulation.

- (✓) Wrap the end without the shield around the curved lead of the resistor and solder as shown in Detail 20C. Use only enough heat to cause a good solder connection, being careful not to melt the inner insulation of the shielded cable.

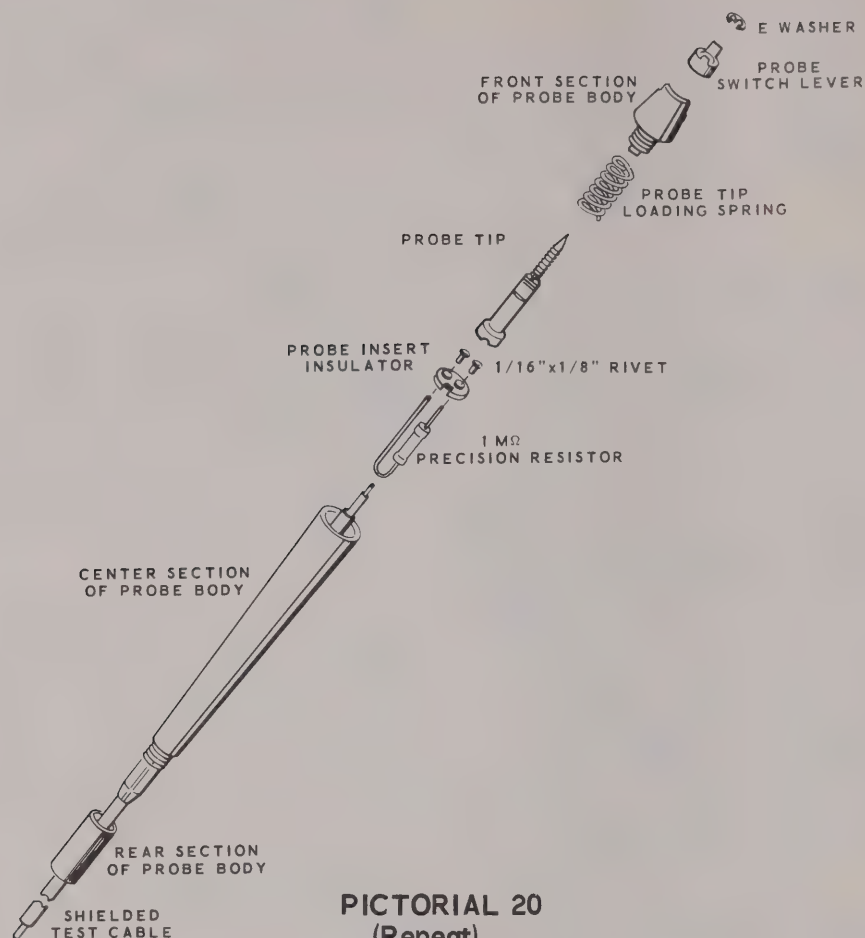


Detail 20C

- (✓) Refer to Details 20D and 20E for assembly of the front section of the probe. Check the probe tip for burrs and, if necessary, remove any burrs before assembly. Assemble the probe tip, the spring, the front section of the probe body, and the switch lever as shown.

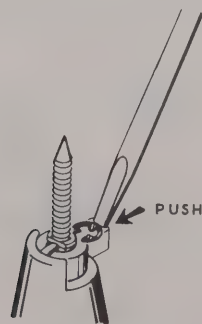


Detail 20D



**PICTORIAL 20**  
(Repeat)

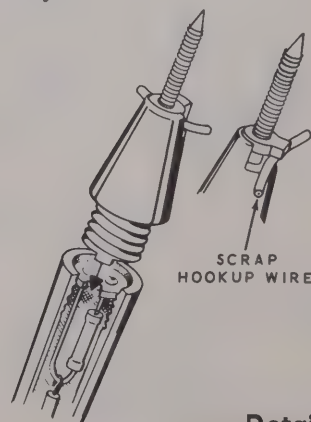
- (✓) Push the switch lever flush against the front section of the probe body so that the small retaining ring notch in the tip is exposed. While holding the tip in firmly against the spring pressure with one hand, use a screwdriver or penknife to insert the retaining E washer into the notch in the tip as shown in Detail 20E. When this E washer is securely in place, the tip will be locked to the front section of the probe body.



**Detail 20E**

Refer to Detail 20F for final assembly of the test probe.

- (✓) Pull the switch lever forward against the spring tension and temporarily insert a scrap piece of hookup wire between the switch lever and the front section of the probe body.



**Detail 20F**



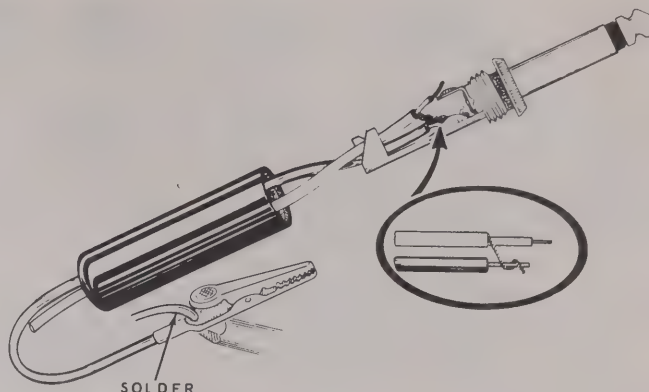
- ( ) Slip the center section of the probe body onto the shielded cable.
- (✓) Gently pulling the shielded cable from the back of the center section, align the insert insulator flush with the front of the center section. Do not pull the insert insulator all the way into its final shoulder seat.
- (✓) Insert the tab on the front section of the probe body into the notch in the insert insulator. Holding the front section stationary, screw the center section onto the front section, thus pushing the insert insulator down to its final seat. It is imperative that the final probe assembly be carried out in this manner; otherwise, proper connection between the rivet heads and the front section of the probe will not be made.
- (✓) Remove the scrap hookup wire.

NOTE: If the gap between the front and middle sections is not considerably less than  $1/16"$ , the tab is not properly seated in the notch and the above steps must be repeated. Also, when properly assembled, the switch lever will noticeably "detent", or drop into place at both extreme switch positions.

- (✓) Slip the rear section of the probe onto the cable and screw it onto the center section.

This completes the assembly of the test probe. The phone plug and alligator clip will now be assembled.

- (✓) Strip  $1/2"$  of insulation from both ends of the black test lead.
- ( ) Unscrew the cap from the phone plug.
- (✓) Insert the test lead cable and the free end of the shielded cable through the phone plug cap.



Detail 20G

- (✓) Now twist the shield wires of the shielded cable and the wires at the end of the black test lead firmly together and melt a small amount of solder on the combined wires as shown in Detail 20G. Also melt a small amount of solder on the inner conducting wire of the shielded cable. Take care not to melt the inner insulation.

In the following step, you will connect the prepared cables to the phone plug as shown in Detail 20G. To avoid overheating the cable insulation, first apply a film of solder to the phone plug terminals and heat thoroughly; then hold the wires to the phone plug and apply just enough heat to melt the solder.

- (✓) Refer to Detail 20G and solder the two twisted wires to the phone plug. Be careful not to melt or burn the inner plastic insulation of the shielded cable. Then solder the inner wire of the shielded cable as shown. Be sure the phone plug body will still fit over the wires. Use only enough heat to melt the solder and make a good connection.
- (✓) After the wires have completely cooled, use pliers to bend the tabs on the phone plug over lightly to secure the black cable. Then screw the cap onto the phone plug.
- (✓) Melt a small amount of solder on the strands of the free end of the black test lead and solder it to the alligator clip without the threaded insert as shown.

This completes the phone plug assembly.

## CALIBRATION

The following steps use a minimum of equipment to calibrate the DC, Ohms, and AC sections of the Solid State VOM. If precision standards are available, perform the following calibration steps first, and then make final touch up adjustments using the precision standards.

These steps should be performed carefully and accurately, since this determines the overall accuracy of the VOM. Refer to Figures 1 (fold-out from Page 35) and 2 while performing the following steps. If at any time you do not obtain the results called for in a step, refer to the In Case of Difficulty section (Page 45) to correct the problem.

### DC CALIBRATION

- ( ) Turn all switches to their maximum counterclockwise position.
- ( ) Turn all controls on the subpanel to their maximum counterclockwise position.
- ( ) Set the AC-DC Mode switch to DC+.
- ( ) Turn the ZERO control fully clockwise (toward the top of the panel) by turning the thumbwheel knob up until the ball bearings on the rear of the control stop turning.
- ( ) Check the zero position of the meter pointer. If the pointer does not rest directly over the zero marks at the left end of the meter scales, carefully turn the Meter Zero Adjust screw while lightly tapping the face of the meter with your finger.
- ( ) Connect the line cord plug to an AC outlet (120 volt, if you wired the Voltmeter for 120 volt operation, or 240 volt if wired for 240 volt operation).
- ( ) Turn the VOM on by switching the OFF-LINE-BATT switch to the LINE position.
- ( ) Very slowly turn the DC BIAS control clockwise until the meter indicates 0.

- ( ) Turn the Volts Range switch to the 1.5 position.
- ( ) Turn the test probe switch to DC and plug the phone plug into the VOM input jack.
- ( ) Connect the common (black) test lead to the minus (-) lead and the tip of the test probe to the positive (+) lead of the mercury cell holder mounted on the circuit board.
- ( ) Adjust the DC CAL control until the meter indicates 1.35 volts on the 1.5 volt DC scale.
- ( ) Disconnect the test probe and test lead from the mercury cell holder and clip the test lead to the probe tip.

NOTE: The intent of the next two steps is to provide an operating point so that a midscale indication can be reached on DC+, but not DC-. FET characteristics can vary widely. Because of this, a suitable DC BIAS setting can be found by adjusting it for more than midscale on DC+ and less than midscale on DC-.

- ( ) Very slowly turn the DC BIAS control clockwise until the meter indicates approximately 40 to 45 on the 50 DC scale. (Any reading more than 25 is satisfactory.)
- ( ) Turn the ZERO control thumbknob down until the meter indicates "0." Then turn the AC-DC Mode switch to DC- and continue to turn the ZERO knob down until the ZERO control is fully counterclockwise. The meter should now indicate upscale to approximately 15 to 20 on the 50 DC scale. (Any reading less than 25 is satisfactory.)
- ( ) Turn the ZERO knob clockwise (up) again, and adjust for a zero meter indication.
- ( ) Alternately switch the AC-DC Mode switch between DC-, and DC+. The meter should remain at zero in both positions when the zero knob is properly adjusted. NOTE: There may be a momentary fluctuation as capacitors charge, but the meter should then return to zero.



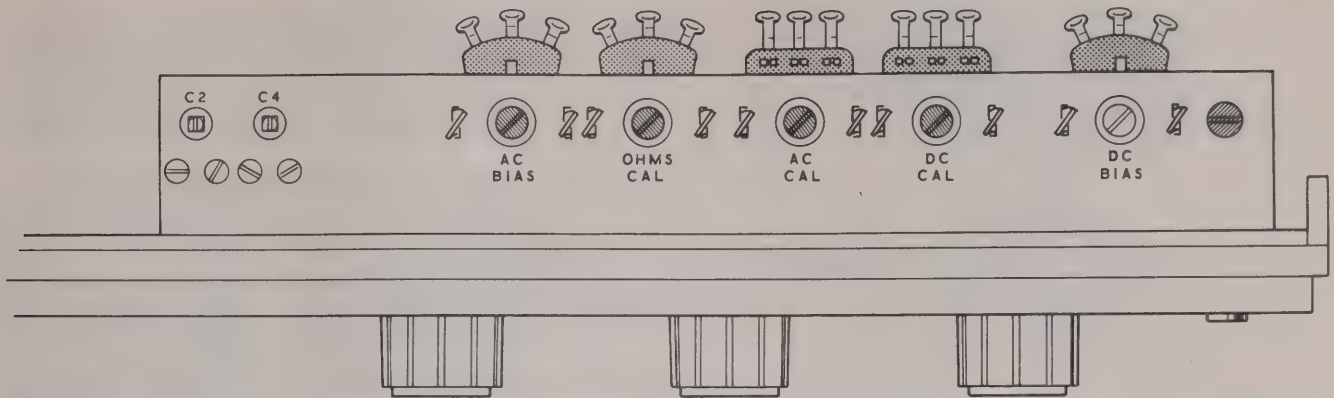


Figure 2

NOTE: In the following steps, you will recheck the DC calibration of the VOM.

- (X) Turn the AC-DC MODE switch to the DC+ position and turn the Volts Range switch to the 1.5 positions.
- ( ) Turn the test probe switch to DC.
- (X) Connect the common (black) test lead to the minus (-) lead and the tip of the test probe to the positive (+) lead of the mercury cell holder mounted on the circuit board.
- (X) Adjust the DC CAL control until the meter indicates exactly 1.35 volts on the 1.5 volt DC scale.
- (X) Disconnect the test probe and test lead from the mercury cell holder.

NOTE: The small red dot at the right-hand end of the 15 DC scale represents 1.55 volts when

the VOLTS Range switch is in the 1.5 position. Fully-charged, unused dry cell batteries should measure 1.55 volts DC. This offers a convenient way to check DC calibration at any time.

## AC CALIBRATION

The AC calibration of your Solid State VOM consists of the following: the AC Bias control adjustment, AC Calibration control adjustment, and the adjustment of the AC frequency compensating trimmer capacitors, C2 and C4. The AC Bias and AC Calibration adjustments can be made quite accurately without special equipment. However, for maximum accuracy, and for the adjustment of the AC frequency compensating trimmers, an AC and DC voltmeter, an audio square-wave generator, and an oscilloscope, will be required.

## AC Bias Control Adjustment

- ( ) Turn the VOA Function switch to the VOLTS position, and the AC-DC Mode switch to DC-.
- ( ) Turn the VOLTS Range switch to the 5 position.

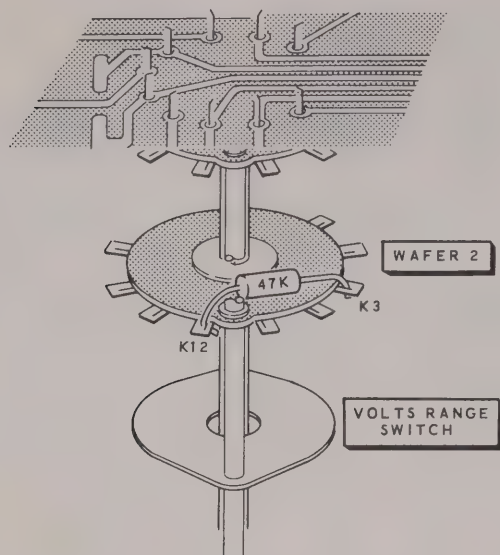


Figure 3

The next three steps are for an AC Bias adjustment with an accurate DC Voltmeter. If a separate voltmeter is not available, omit these three steps and proceed to AC Bias Control Adjustment, Alternate Method.

1. ( / ) Connect the positive test lead of the DC voltmeter to lug 3 on wafer 2 of VOLTS Range switch K. See Figure 3.
2. ( / ) Connect the negative test lead of the DC voltmeter to lug 12 on wafer 2 of the VOLTS Range switch.
3. ( / ) Adjust the AC BIAS control (on the sub-panel) until the meter reads exactly 6 volts. Note that the meter responds slowly to this adjustment.

#### AC Bias Control Adjustment, Alternate Method

The next three steps are to be used only if a separate DC voltmeter is not available. The results obtained in this adjustment method may not be quite as accurate as the results obtained with a separate DC voltmeter but are well within the specifications.

- 1A ( / ) Set the Solid State VOM test probe switch to the DC position; then touch the tip of the probe to lug 12 on wafer 2 of VOLTS Range switch K. (See Figure 3.) Carefully observe the meter reading on the 5 volt scale.

- 2A ( / ) Change the AC-DC Mode switch to DC+. Now touch the tip of the test probe to lug 3 on wafer 2 of the VOLTS Range switch and observe the meter reading.

- 3A ( / ) While you hold the test probe on lug 3 on wafer 2 of the VOLTS Range switch, adjust the AC BIAS control (on the sub-panel) until the meter reads exactly 6 volts more positive than it did when you touched the probe to lug 12 in a previous step. For example, if the reading on lug 12 was -2.5 volts, adjust the AC BIAS control to produce a reading of +3.5 on lug 3.

- ( / ) Disconnect the Voltmeter leads, or the test probe, from the lugs of the VOLTS Range switch.

#### AC Calibration Control Adjustment

For maximum accuracy in adjusting the AC Calibration control, an AC voltage of known accuracy is required. You may wish to use another accurate AC voltmeter to measure the line voltage, for example, and then use this voltage to calibrate your VOM.

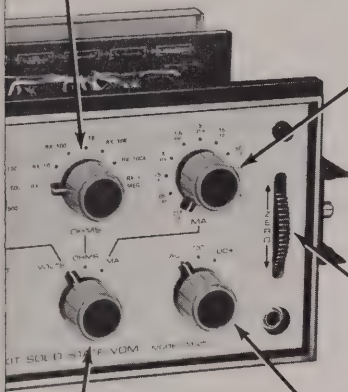
**WARNING:** Use extreme care when measuring line voltage to prevent personal shock or instrument damage.

- ( / ) Set the VOA Function switch to the VOLTS position, and the AC-DC Mode switch to AC.
- ( / ) Set the VOLTS Range switch to the range that will give approximately a 3/4 scale reading for your calibrating voltage. For example, if you use a 120 volt AC line for calibration, set the VOLTS Range switch to 150.
- ( / ) Set the test probe switch in the AC-OHMS position.
- ( / ) Connect the test probe and common lead to the calibrating voltage.
- ( / ) Adjust the AC CAL control until the meter indicates the calibrating voltage. If you first measured the calibrating voltage with another AC voltmeter, adjust the AC CAL control until your Solid State VOM indicates the same voltage.



**RANGE SWITCH**  
 selects the multiplier  
 ohms measurement.

**MA RANGE SWITCH**  
 This switch selects the full scale  
 range for milliampere measure-  
 ments.



**ZERO CONTROL**  
 This control sets the meter position  
 to zero on the calibrated zero center  
 scale. It also adjusts the meter to the  
 left end zero position.

**FUNCTION SWITCH**  
 selects the measure-  
 ment to be made.

**AC-DC MODE SWITCH**  
 This switch is used to select the  
 mode of voltage measurement. Ei-  
 ther AC, DC+, or DC-.

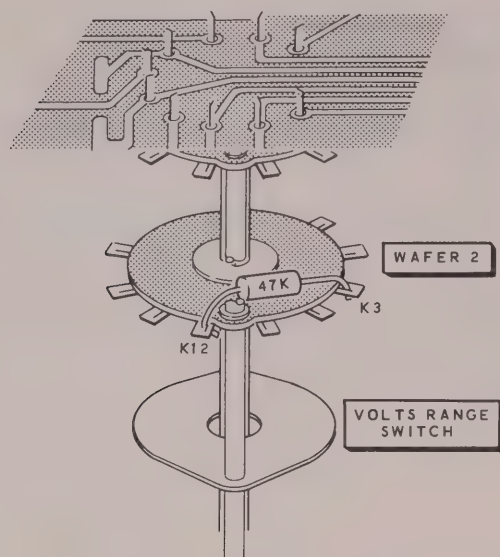


Figure 3

The next three steps are for an AC Bias adjustment with an accurate DC Voltmeter. If a separate voltmeter is not available, omit these three steps and proceed to AC Bias Control Adjustment, Alternate Method.

1. ( ) Connect the positive test lead of the DC voltmeter to lug 3 on wafer 2 of VOLTS Range switch K. See Figure 3.
2. ( ) Connect the negative test lead of the DC voltmeter to lug 12 on wafer 2 of the VOLTS Range switch.
3. ( ) Adjust the AC BIAS control (on the sub-panel) until the meter reads exactly 6 volts. Note that the meter responds slowly to this adjustment.

#### AC Bias Control Adjustment, Alternate Method

The next three steps are to be used only if a separate DC voltmeter is not available. The results obtained in this adjustment method may not be quite as accurate as the results obtained with a separate DC voltmeter but are well within the specifications.

- 1A ( ) Set the Solid State VOM test probe switch to the DC position; then touch the tip of the probe to lug 12 on wafer 2 of VOLTS Range switch K. (See Figure 3.) Carefully observe the meter reading on the 5 volt scale.

- 2A ( ) Change the AC-DC Mode switch to DC+. Now touch the tip of the test probe to lug 3 on wafer 2 of the VOLTS Range switch and observe the meter reading.
- 3A ( ) While you hold the test probe on lug 3 on wafer 2 of the VOLTS Range switch, adjust the AC BIAS control (on the sub-panel) until the meter reads exactly 6 volts more positive than it did when you touched the probe to lug 12 in a previous step. For example, if the reading on lug 12 was -2.5 volts, adjust the AC BIAS control to produce a reading of +3.5 on lug 3.
- ( ) Disconnect the Voltmeter leads, or the test probe, from the lugs of the VOLTS Range switch.

#### AC Calibration Control Adjustment

For maximum accuracy in adjusting the AC Calibration control, an AC voltage of known accuracy is required. You may wish to use another accurate AC voltmeter to measure the line voltage, for example, and then use this voltage to calibrate your VOM.

**WARNING:** Use extreme care when measuring line voltage to prevent personal shock or instrument damage.

- ( ) Set the VOA Function switch to the VOLTS position, and the AC-DC Mode switch to AC.
- ( ) Set the VOLTS Range switch to the range that will give approximately a 3/4 scale reading for your calibrating voltage. For example, if you use a 120 volt AC line for calibration, set the VOLTS Range switch to 150.
- ( ) Set the test probe switch in the AC-OHMS position.
- ( ) Connect the test probe and common lead to the calibrating voltage.
- ( ) Adjust the AC CAL control until the meter indicates the calibrating voltage. If you first measured the calibrating voltage with another AC voltmeter, adjust the AC CAL control until your Solid State VOM indicates the same voltage.



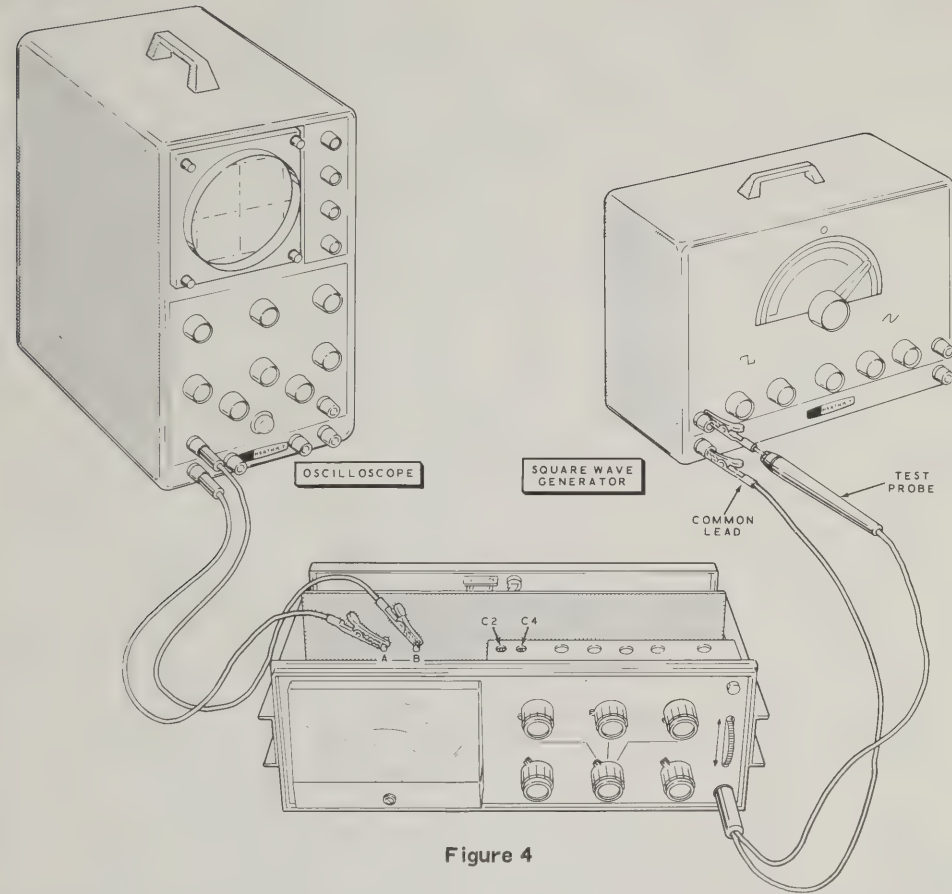


Figure 4

( ) Disconnect the test probe and common lead from the calibrating voltage.

#### Frequency Compensating Trimmer Adjustment

This adjustment improves the accuracy of voltage measurements at higher frequencies. It compensates for capacitive effects of the probe and circuits for different AC voltage ranges. An audio square-wave generator and an oscilloscope are required to properly adjust the frequency compensating trimmer capacitors.

NOTE: If an audio square-wave generator and an oscilloscope are not available, and only average accuracy at higher frequencies will satisfy your

needs, set trimmer capacitors C2 and C4 so their slots are perpendicular (at right angles) to the front panel. Then, omit the following Frequency Compensating Trimmer Adjustments and proceed to Ohms Calibration.

Refer to Figure 4 for the following steps.

- ( ) Connect the input of an oscilloscope to terminal pins A and B on the circuit board.
- ( ) Be sure the VOM test probe switch is in the AC-OHMS position.
- ( ) Connect the VOM test probe and common test lead to the square-wave output of the audio generator.

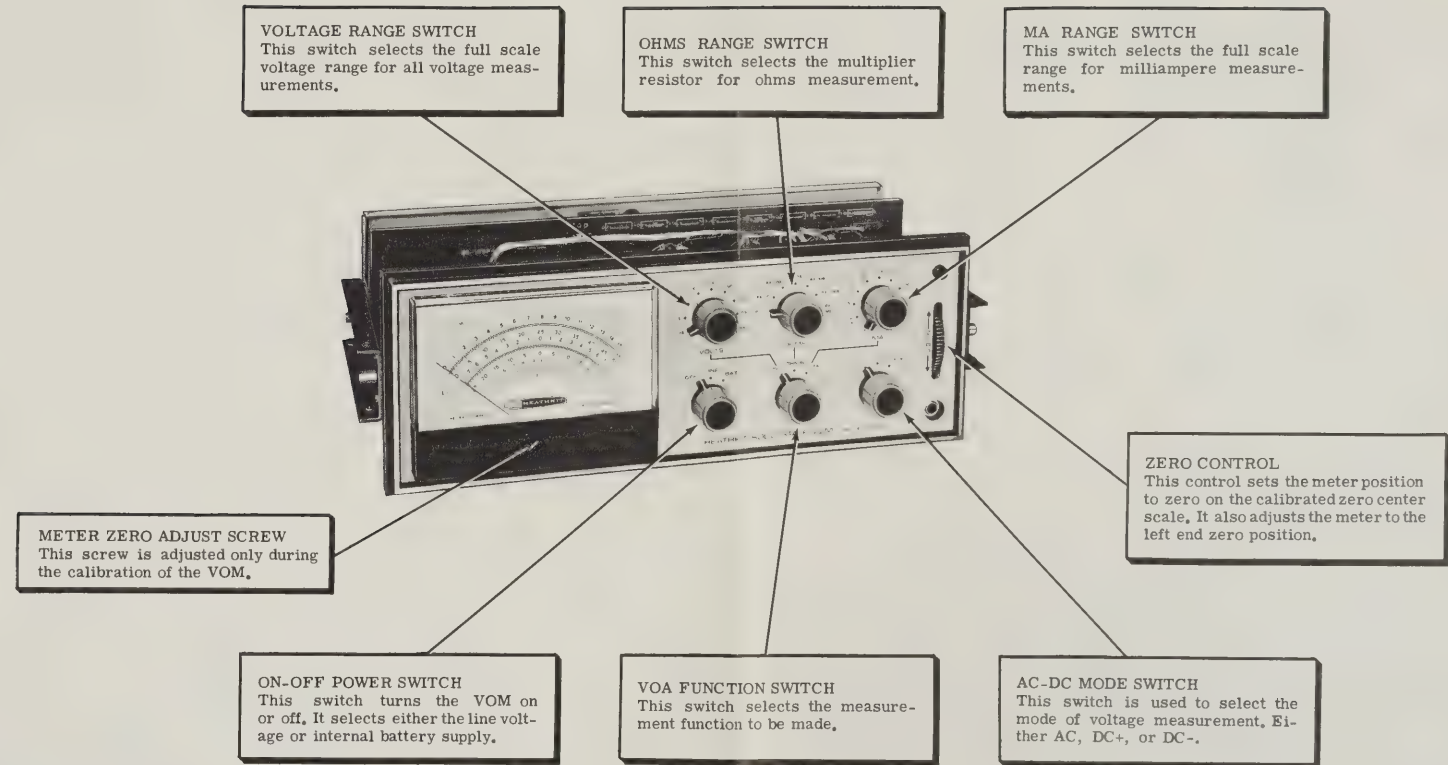


FIGURE 1

- ( ) Set the VOLTS Range switch to 150 and the AC-DC Mode switch to AC.
- ( ) Turn on the VOM, oscilloscope, and generator.
- ( ) After a brief warmup, adjust the generator output for approximately a 10 volt signal at 1 kHz, or at the frequency you will encounter the most when you measure AC voltages.
- ( ) Adjust the oscilloscope to display the waveform clearly.
- ( ) Adjust trimmer capacitor C2 until the waveform on the oscilloscope looks like the one shown in Figure 5. The horizontal lines should be straight and flat.
- ( ) Change the VOLTS Range switch to the 50 position. A larger display should now appear on the oscilloscope.
- ( ) Adjust the oscilloscope to give a clear display of the waveform.
- ( ) Adjust trimmer capacitor C4 until the waveform on the oscilloscope is straight and flat.
- ( ) Repeat the adjustment of C2 in the 150 volt range, and C4 in the 50 volt range, until the waveform on the oscilloscope is straight and flat for both ranges.
- ( ) Disconnect the square-wave generator and oscilloscope from the Solid State VOM.

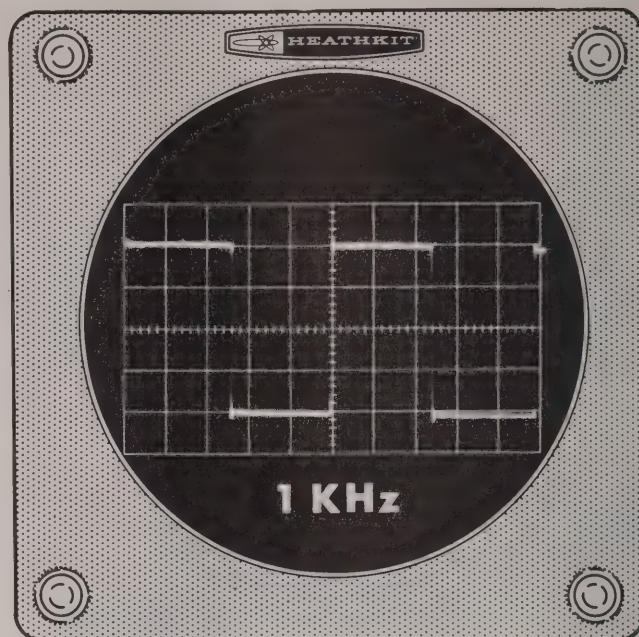


Figure 5

### OHMS CALIBRATION

Be sure to zero the meter before you begin the Ohms Calibration steps, and whenever you prepare to use any function of your Solid State VOM hereafter. This is done by turning the VOA Function switch to VOLTS, and the AC-DC Mode switch successively to DC- and DC+. Then, adjust the Zero thumbknob so the meter pointer remains at zero for both positions of the switch.



- ( ) Set the test probe switch to AC-OHMS.
- ( ) Turn the VOA Function switch to Ohms.
- ( ) Turn the OHMS Range switch to RX1.
- ( ) Adjust the OHMS CAL control until the meter pointer rests directly over the last green mark at the right-hand end of the OHMS scale.
- ( ) Clip the common test lead onto the tip of the test probe. The meter pointer should now fall nearly to zero. NOTE: The pointer may not fall all the way to zero when the OHMS Range switch is in the RX1 position. This is due to the resistance of the test leads. However, this resistance should not be more than .2 ohms.
- ( ) Turn the OHMS Range switch clockwise through all of its positions. The meter pointer should indicate "O" for all switch positions except RX1.
- ( ) Turn the OHMS Range switch to the RX1 MEG position.

In the next steps you will use the resistor that is built into the test probe as a reference resistance.

- ( ) Set the test probe switch to DC. The meter pointer should now fall directly over the 1 on the OHMS scale.
- ( ) Turn the OHMS Range switch to RX100K, and then to RX10K. The pointer should indicate 10 and 100 for these two switch positions.

NOTE: If there is more than a slight error in the 1, 10, and 100 readings obtained in the last three clockwise positions of the VOLTS Range switch, set the OHMS CAL control for a compromise reading between the three positions. Do not change the Zero adjust thumbknob while making resistance tests.\*

- ( ) Disconnect the common test lead clip from the tip of the test probe and turn off the VOM.

This completes the calibration of your Solid State VOM. The calibration should be rechecked after a few weeks of use since it may change slightly due to aging of the components. Proceed to the Final Assembly section.

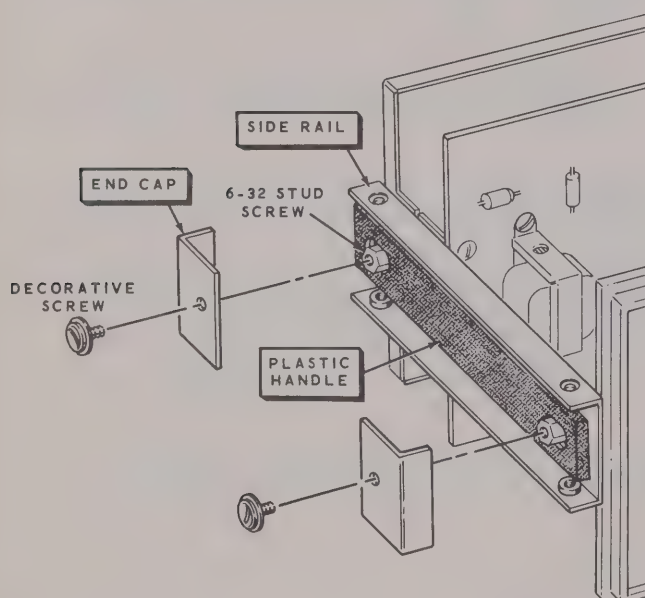
\*For more accurate resistance measurements with the Solid State VOM, develop the habit of first setting the meter to "0" with the Zero thumbwheel knob, with the VOA Function switch set on Volts. Then check the Ohms calibration by using the 1 M $\Omega$  resistor that is built into the test probe. Turn the Ohms range switch to RX1 Meg, RX100K, and RX10K; the meter should indicate 1, 10, and 100 for these positions.

## FINAL ASSEMBLY

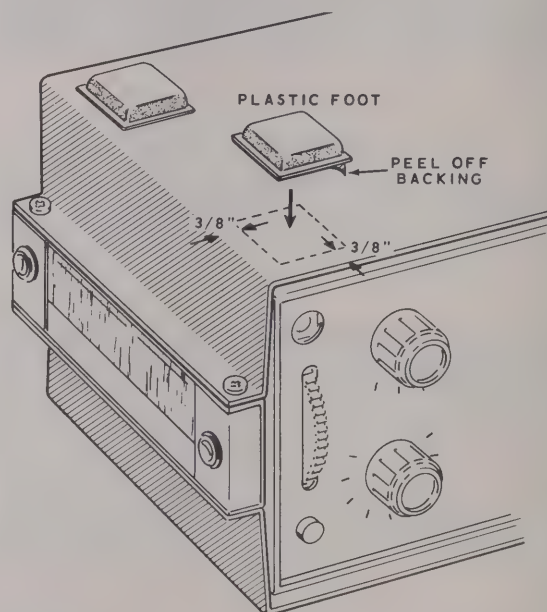
Refer to Pictorial 21 for the following steps.

- ( ) Refer to Detail 21A and place the handle strap over the 6-32 stud screws as shown. Then place an end cap in position on each end of the side rail and secure them with decorative screws. Use a penny to tighten the screws.
- ( ) In the same manner, install a handle strap and two end caps on the side rail at the other end of the VOM.
- ( ) Place one of the cabinet shells over the VOM chassis with the sloping edge toward the front. Then secure it with two 6-32 x 1/4" phillips head screws at each end as shown in Pictorial 21.

- ( ) Turn the VOM over and install the other cabinet shell. Use two 6-32 x 1/4" phillips head screws at each end.
- ( ) Refer to Detail 21B and install a plastic foot near each corner on the bottom cabinet shell. Remove the paper backing; then press the foot onto the cabinet shell in the position shown. A plastic foot can be moved, if necessary, up to one-half hour after the backing is removed. After this, the adhesive permanently bonds the foot to the cabinet shell.

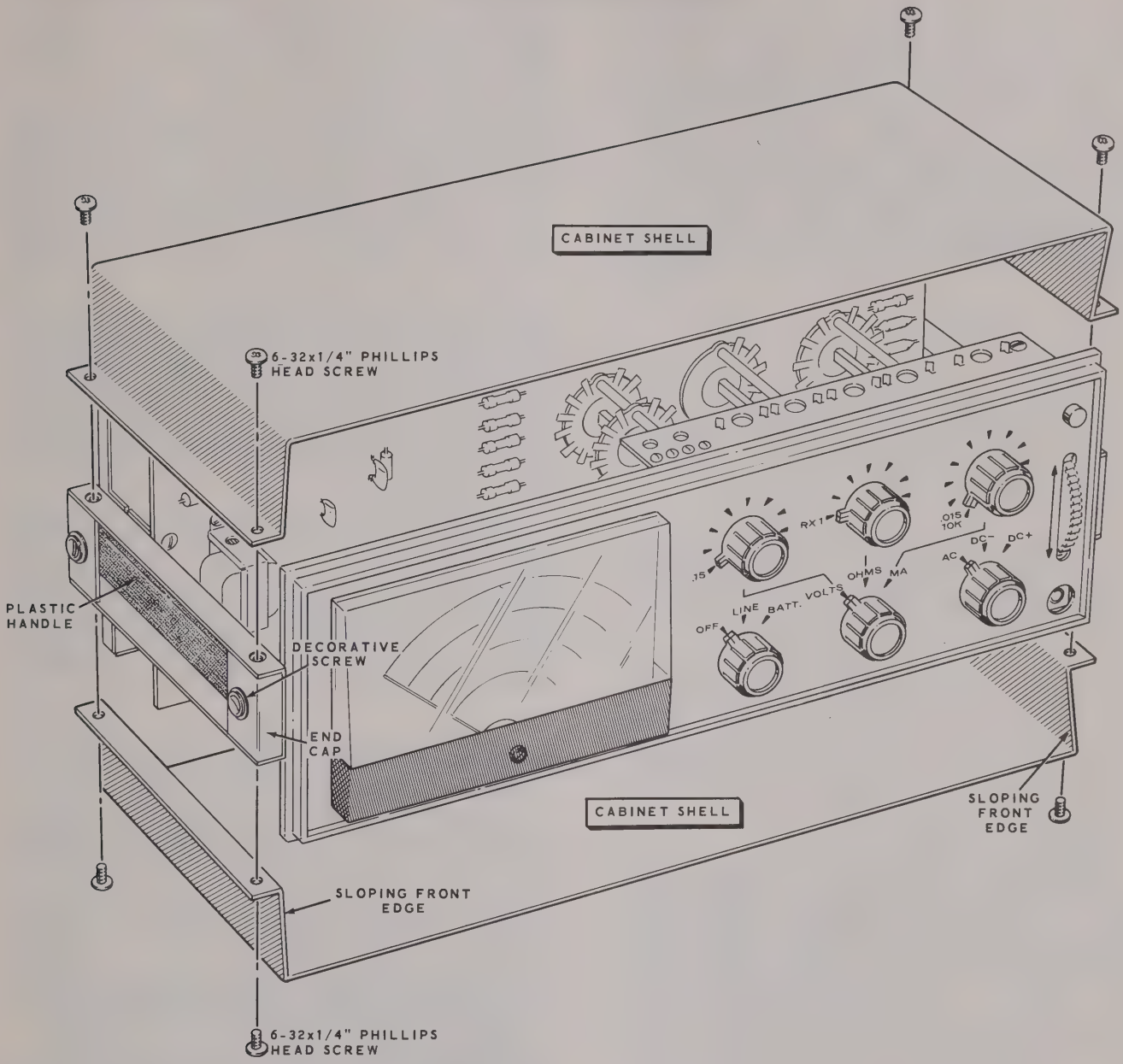


Detail 21A



Detail 21B





PICTORIAL 21

## OPERATION

The power consumption of the Solid State VOM is very low and there is no objection to leaving the instrument on continuously during the daily work period rather than turning it off each time a measurement function is completed. However, to avoid ohmmeter battery drain, do not leave the Function switch in the Ohms position longer than necessary to make resistance measurements.

### SAFETY PRECAUTIONS

**CAUTION:** It is good practice to observe certain basic rules of operating procedure anytime voltage measurements are to be made. Always handle the test probe by the insulated housing only and do not touch the exposed tip portion.

When high voltage measurements are going to be made, remove operating power to the unit under test before connecting the test leads. If this is not possible, be careful to avoid accidental contact with nearby objects which could provide a ground return path. When working on high voltage circuits, play safe. Keep one hand in your pocket to minimize accidental shock hazard, and be sure to stand on a properly insulated floor or floor covering.

### COMBINATION PROBE

The combination AC-OHMS DC test probe eliminates two of the usual three test jack installations on the VOM front panel. The probe switch should be set to AC-OHMS for all AC voltage measurements, resistance measurements, and both AC and DC current measurements. The DC position of the probe switch is used only for DC voltage measurements. The probe can be clipped onto any lead in the circuit, by installing the alligator clip on the threaded probe tip as shown in Figure 6.

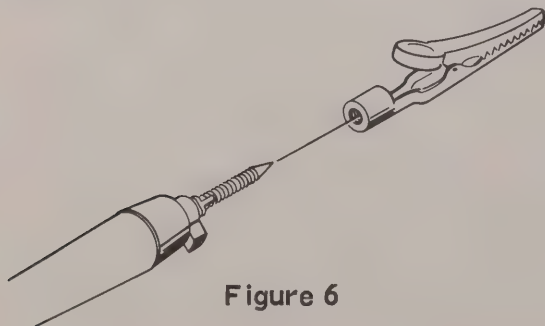


Figure 6

### READING THE METER

The voltage markings on the Range switch refer to full scale readings on the meter. There are two AC scales, printed in red, that read 0-15 and 0-50. The DC scales are printed in black and also read 0-15 and 0-50. Two additional DC scales are calibrated for zero center readings.

To read voltage on the .15 volt range, read the 15 scale and move the decimal two places to the left. For example, a meter reading of 6 would indicate an actual measurement of .06 volt. For the .5 volt range, read the 50 scale. For example, a meter reading of 30 would indicate a measurement of .3 volt.

To read voltage on the 1.5 volt range, read the 15 scale and move the decimal one place to the left. For example, a meter reading of 8 would indicate an actual measurement of .8 volt. For the 5 volt range, read the 50 scale. For example, a meter reading of 40 would indicate a measurement of 4 volts.

On the 15 V range, read the 15 scale directly. On the 50 V range, read the 50 scale directly. On the 150 V range, read the 15 scale and move the decimal one place to the right. For example, a meter reading of 13 would indicate 130 volts. On the 500 V range, read the 50 scale and move the decimal point one place to the right. For example, a meter reading of 40 would indicate 400 volts. When using the 1500 V range, use the 15 scale and move the decimal two places to the right. For example, a meter reading of 12 would indicate 1200 volts.

Milliampere readings are indicated on either the AC or DC scale, depending upon whether AC or DC current is being measured. The scales are read the same as when measuring volts.

Resistance measurements are read on the top scale, which is lettered in green. The OHMS Range switch markings are multipliers for the Ohms scale on the meter. In the RX1 position, the scale is read directly in ohms. The RX10 position indicates that the meter reading is to be multiplied by 10, or simply place one zero after the meter reading. As an example, suppose you measured a resistor with the OHMS Range switch in the RX10 position and the meter reading was



15. Multiply this reading by 10 (or add one zero) and know that the actual resistance is 150 ohms. The rest of the OHMS Range switch positions also show the multiplier to use. Another example would be with the OHMS Range switch in the RX1 Meg position. Here the meter is read directly in megohms, or the meter reading multiplied by 1,000,000 (add six zeros) for the resistance in ohms.

### CENTER SCALE "0" POSITION

Your Solid State VOM features a convenient, calibrated zero center scale. See Figure 7. The front panel ZERO control is used to adjust the meter pointer for center scale zero deflection. The two DC zero center scales are calibrated 7.5-0-7.5 and 25-0-25. The 7.5-0-7.5 scale is used with the .15, 1.5, 15, 150, and 1500 Range switch positions, and the 25-0-25 scale is used with the .5, 5, 50, and 500 Range switch positions. The scales are read as for normal DC voltage measurements, except that zero is in the center. Center scale can only be reached with the AC-DC Mode switch in the DC+ position, therefore positive voltages will deflect the meter to the right of zero, while negative voltages deflect the meter to the left.

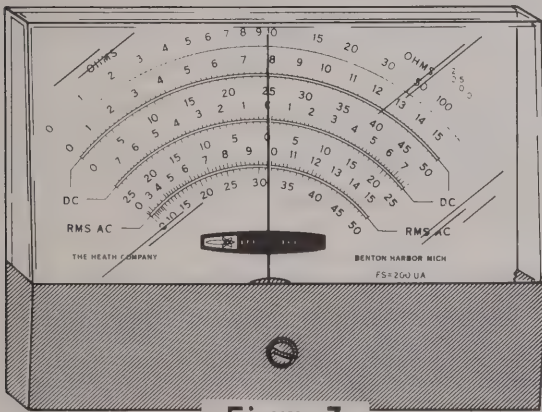


Figure 7

The center scale zero will be useful as a null indicator in discriminator adjustments, for bias measurements, or in any application where polarity reversals may occur.

### DC VOLTAGE MEASUREMENTS

The Solid State VOM has many advantages over the nonelectronic voltmeter. The greatest advantage is its ability to measure voltages without significantly loading the circuit being tested.

This characteristic enables the voltage to be measured accurately. This is especially desirable in such high impedance circuits as resistance coupled amplifiers and AVC networks, and on oscillator grids.

To illustrate this advantage of the Solid State VOM, assume that a resistance-coupled audio amplifier with a 500 K $\Omega$  plate load resistor is operating from a 100 volt plate source. See Figure 8.

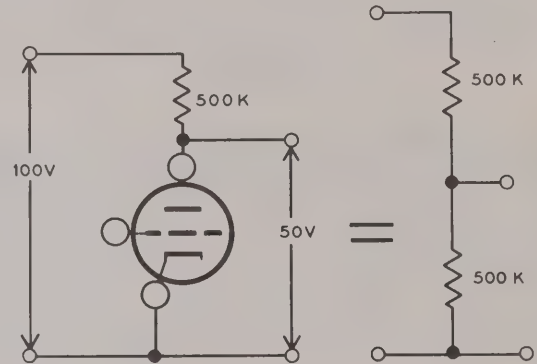


Figure 8

Assuming that the actual plate voltage in this case is 50 volts, therefore, the tube acts as a 500 K $\Omega$  resistor. When measuring the plate voltage with a conventional 1000 ohms-per-volt meter on the 100 volt scale, the meter represents a 100 K $\Omega$  resistor placed in parallel with the tube. See Figure 8A. The voltage on the plate, as shown on the meter, would then be 14.3 volts. This large amount of error is caused by the shunt resistance of the meter.

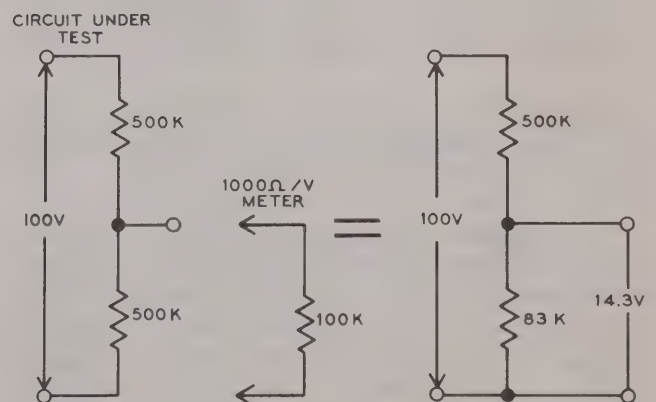


Figure 8A

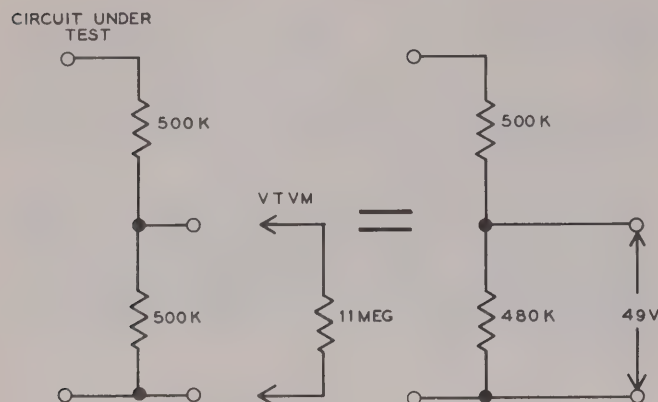


Figure 8B

When the Solid State VOM is used on any DC voltage scale, the full 11 megohms input resistance is placed in parallel with the tube. See Figure 8B. A plate voltage of about 49 volts is then shown on the meter, only 2% lower than the normal operating voltage. Thus, accurate readings in this instance can be obtained only with a high resistance device such as the Solid State VOM.

To measure positive DC voltages, set the VOA Function switch to volts and the AC-DC Mode switch to DC+. Connect the common test lead to the "cold" (common) side of the voltage. In transformer-operated equipment, common is usually the chassis.

Set the Volts Range switch to a range higher than the voltage to be measured. If the voltage is unknown, set the VOLTS Range switch to the 1500 volt range. Set the test probe switch to DC, and touch the tip of the probe to the voltage point. A meter reading in the upper portion of the meter scale is easier to read. If the meter does not read in the upper 2/3 of the meter scale, reduce the setting of the Volts Range switch.

To measure negative DC voltages, place the AC-DC Mode switch in the DC- position and make the measurements as described above.

The voltage ranges provided by the VOM were selected for the greatest ease in reading and for convenience in making voltage measurements. The low ranges (.15 to 50) will be very handy for transistor circuits and for bias and filament voltage measurements. The middle ranges (50 and 150) ranges will most often be used when checking AC-DC type equipment. The higher

ranges will be used most when measuring B+ voltages in transformer-operated equipment.

## AC VOLTAGE MEASUREMENTS

To measure AC voltage with the VOM, set the VOA Function switch to Volts and the AC-DC Mode switch to AC. Connect the common lead to the common or "cold" side of the voltage to be measured.

Set the Volts Range switch to a range greater than the voltage to be measured, if an approximate voltage is known. If the voltage is completely unknown, set the Volts Range switch to 1500 V. Then, with the test probe in the AC position, touch the point in the circuit where the voltage is to be measured. If the meter moves less than 1/3 of full scale, switch to the next lower range. The maximum AC voltage that can be safely measured with your VOM is 1500 volts, and this limit must not be exceeded.

Almost any type of AC voltage, filament voltage, power line voltage, noise voltage, or even output or gain measurements can be made quickly and accurately with your Solid State VOM. It is calibrated to read the root-mean-square (rms) value of a pure sine wave. This is 70.7% of the peak voltage. When measuring odd-shaped waveforms (square waves, sawtooth waves or pulses) the meter reading must be given special interpretation since meter deflection is proportional to the average value of the input waveform. The complex waveform in Figure 9, for example, shows a spike (peak) that may be several times as large as the average value. Since the spike is of short duration,

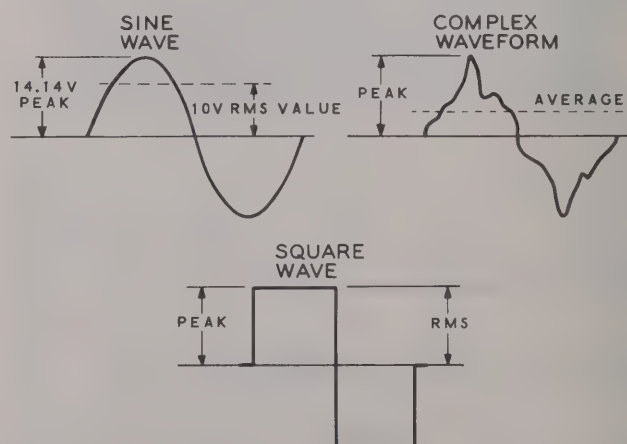


Figure 9



the average value of the overall waveform is barely affected. On the other hand, the square wave would present an rms value equal to the peak value.

When connecting the VOM to the circuit under test, the VOM input resistance and input capacitance are effectively placed in parallel with the voltage source. In some cases, this can load the circuit and change the actual voltage to be measured. At low frequencies, such as the power line frequencies of 50 or 60 Hz, the effects of capacitance loading may usually be disregarded. Thus, the load the VOM presents to the circuit being measured is about the same as a 10 megohm resistor. At higher frequencies, the capacitive reactance decreases. At 10 kHz for example, it is approximately 100 K $\Omega$ . Such a value may seriously affect the voltage at the point of measurement.

The amount of loading presented by the input capacitance and resistance of the VOM to the circuit being tested is determined by the impedance of the circuit being tested. In low impedance circuits, such as 50 to 600  $\Omega$  no noticeable error is introduced in the voltage reading through circuit loading. These circuits will only begin to be loaded at frequencies that approach the upper limit of the Solid State VOM's frequency response.

Remember, as a general rule, that frequency response and loading may affect the accuracy of your voltage readings. There will be a resistive loading of 10 megohms regardless of frequency. The amount of capacitive loading will depend on the frequency involved. The actual capacitance of the instrument and the leads may also affect the tuning of low capacitance resonant circuits.

You should know the values in the circuit under test and the values of the input resistance and capacitance of the VOM. This will permit you to make valid readings over a wide range of impedances within the full frequency response of the instrument.

The Heathkit Solid State VOM is an extremely sensitive electronic AC voltmeter and, since the human body picks up AC when near any AC wires, the meter will indicate this pickup. Never touch the tip of the probe when the VOLTS Range switch is set to the lower ranges. Zero should be set with the probe shorted to the common clip.

## RESISTANCE MEASUREMENTS

**CAUTION:** Do not attempt to measure resistance in circuits to which power is applied. Always turn off the unit under test and discharge any capacitors in the circuit before making resistance measurements.

To measure resistance with the VOM, set the VOA Function switch to OHMS and set the OHMS Range switch to such a range that the reading will fall as near mid-scale as possible. Then connect the common lead to one side of the resistor or circuit to be measured and touch the test probe to the other side. Read resistance on the OHMS scale and multiply the reading by the proper factor as shown on the OHMS Range switch setting.

The ohmmeter places a voltage of about 70 millivolts or less across the test component. This low voltage permits resistance measurements in solid-state circuits, as it is not sufficient to cause transistors to conduct and present a shunt to the circuit. However, diodes or transistors can not be checked for junction resistance, since the applied voltage is so low that these devices will not conduct in either direction and therefore appear to be open.

**NOTE:** Although a battery is used to measure resistance, the indication is obtained through the electronic meter circuit; therefore the VOM must be turned on. Some ohmmeter battery current is drawn whenever the instrument is turned on and the VOA Function switch is in the OHMS position. To save battery life when you are not using the ohmmeter, NEVER LEAVE THE VOA FUNCTION SWITCH IN THE OHMS POSITION.

## AC-DC CURRENT MEASUREMENTS

Current measurements up to 1500 milliamperes can be made with the VOM. It is important that the 1 megohm resistor in the test probe be switched out of the circuit for all current measurements. Always place the test probe switch in the AC-Ohms position.

The MA Range switch has two numbers at each of its positions. The heavier number at each position represents the amount of current (in milliamperes) that will give a full scale meter reading at that position. The light numbers show the amount of resistance the meter circuit adds to the circuit under test. This feature will enable you to calculate the actual current in circuits, and compensate for errors due to meter insertion.

## DC Current

To measure DC current, place the VOA Function switch in the MA position and turn the AC-DC Mode switch to DC+. Set the MA Range switch to the position that indicates a higher full scale reading than the current you intend to measure. If you are not sure of the amount of current in the circuit you intend to measure, set the MA Range switch to the 1500 position before you connect the test probe and common test lead into the circuit.

Connect the common test lead and the test probe in series with the circuit being tested. The test probe should be connected to the positive end of the circuit, and the common test lead to the negative end of the circuit. Read the current in milliamperes on the appropriate DC scale. If the current in the circuit is not sufficient to give at least 1/4 scale meter reading, turn the MA Range switch counterclockwise one step at a time until a good reading is obtained. Use the highest range that gives a good reading. This will provide lower insertion resistance and the reading will be more accurate.

## AC Current

AC current measurements are made the same way as DC measurements. Turn the MA Range switch to the desired range. Turn the VOA Function switch to MA and set the AC-DC switch to AC.

Connect the common test lead and the test probe in series with the test circuit. (Polarity is not important in AC measurements.) Then read the current in milliamperes from the proper AC scale.

## ACCURACY

The meter movement is accurate to within  $\pm 2$  percent of full scale. On DC, the  $\pm 1$  percent accuracy of the divider resistors must also be considered, resulting in an accuracy within  $\pm 3$  percent of full scale. On AC, the rectifier circuit contributes variations which result in an accuracy of  $\pm 5$  percent of full scale.

The accuracy on the OHMS range depends primarily on the multipliers which are 1% and the meter movement accuracy, 2%. Because of the nonlinear OHMS scale, the resulting accuracy is not readily expressed in a percentage figure.

NOTE: When comparing this instrument with another voltmeter, consider that the error of the other instrument may be in the opposite direction. Therefore, when comparing two instruments of 5% accuracy, the total difference may be 10%. Critical comparisons should only be made against certified laboratory standards.



## IN CASE OF DIFFICULTY

This section of the Manual is divided into two parts. The first part, titled General Troubleshooting Information, describes what to do about any difficulties that may occur right after the VOM is assembled.

The second part, a Troubleshooting Chart, is provided to assist in servicing if the General information does not clear up the problem, or if difficulties occur after the VOM has been in operation for some time. This Chart lists a number of possible difficulties that could arise, and lists several possible causes.

Before starting any troubleshooting procedure, try to narrow the problem down to a specific area by trying the various functions of the VOM.

### GENERAL TROUBLESHOOTING INFORMATION

The following paragraphs deal with the types of difficulties that may show up right after a kit is assembled. These difficulties are most likely to be caused by assembly errors or faulty soldering. These checks will help you locate any error of this type that might have been made.

1. Recheck the wiring. It is frequently helpful to have a friend check your work. Someone who is not familiar with the unit may notice something consistently overlooked by the builder.
2. About 90% of the kits that are returned for repair do not function properly due to poor connections and soldering. Therefore, many troubles can be eliminated by reheating all connections to make sure that they are soldered as described in the soldering section of the Kit Builders Guide.
3. Check the values of the parts. Be sure that the proper part has been wired into the circuit, as shown in the pictorial diagrams and as called out in the wiring instructions. Pay special attention to resistor values, since there are many resistors of similar value, and they are easily interchanged.
4. Check for bits of solder, wire ends or other foreign matter which may be lodged in the wiring.
5. Check for solder bridges between circuit board foils.
6. If, after careful checks, the trouble is still not located, and another voltmeter is available, check voltage readings in the circuits of your VOM against those shown on the Schematic. NOTE: All voltage readings were taken with an 11 megohm input voltmeter. Voltages may vary as much as  $\pm 20\%$ .
7. A review of the Circuit Description on Page 51, and a study of the Schematic (fold-out from Page 63) will also help you locate a difficulty in the Voltmeter. Refer to the X-Ray View of the circuit board (fold-out from Page 58) to help locate parts.

NOTE: In an extreme case where you are unable to resolve a difficulty, refer to the "Service" section and Warranty of the "Kit Builders Guide", and to the "Factory Repair Service" information on Page 64 of this Manual.

## Troubleshooting Chart

DIFFICULTY	POSSIBLE CAUSE
Completely inoperative in either Line or Batt position of the On-Off Power switch.	<p>NOTE: Possible causes 1, 2, and 3 would only cause trouble in the LINE position of the Power switch.</p> <ol style="list-style-type: none"> <li>1. Power transformer.</li> <li>2. Diode D5.</li> <li>3. Capacitor C16.</li> <li>4. C8 shorted.</li> <li>5. Zener diodes D6 or D7 shorted.</li> <li>6. Meter coil open.</li> <li>7. Transistors Q5 or Q6.</li> <li>8. Dead batteries (Batt position of Power switch only).</li> </ol>
Zero control has no effect.	<ol style="list-style-type: none"> <li>1. Transistor Q7.</li> <li>2. Zero control R45.</li> <li>3. DC Bias control R44 and R46 misadjusted.</li> <li>4. Capacitor C14 shorted.</li> <li>5. Resistor on voltage divider string, R24 through R40. Resistor R41 or R42.</li> </ol>
Inaccurate DC readings.	<ol style="list-style-type: none"> <li>1. DC Calibration control R18 misadjusted.</li> <li>2. Probe switch in wrong position.</li> <li>3. Wrong value or defective resistor in the voltage divider string, R24 through R40.</li> </ol>
AC inoperative.	<ol style="list-style-type: none"> <li>1. Transistor Q1.</li> <li>2. Diodes D1 through D4.</li> <li>3. AC Bias control R6 misadjusted.</li> <li>4. Capacitors C1, C7, C9, C10, or C11.</li> <li>5. Resistor in input voltage divider string, R2 through R4.</li> <li>6. Resistors in output voltage divider string, R9 through R11.</li> <li>7. Transistors Q2 or Q3.</li> </ol>



DIFFICULTY	POSSIBLE CAUSE
Inaccurate AC readings.	<ol style="list-style-type: none"> <li>1. Probe switch in wrong position.</li> <li>2. AC Bias control R6 misadjusted.</li> <li>3. AC Calibration control R17 misadjusted.</li> <li>4. Resistor in voltage divider network R2 through R4 and R9 through R11 (low frequencies).</li> <li>5. Capacitors C2 and C4 misadjusted (high frequencies).</li> </ol>
Ohmmeter inoperative, or inaccurate readings.	<ol style="list-style-type: none"> <li>1. Probe switch in wrong position.</li> <li>2. Ohms calibrate control R20 misadjusted.</li> <li>3. Transistor Q4.</li> <li>4. Batteries E2 and/or E3 weak.</li> <li>5. Resistor R43.</li> <li>6. Resistors in voltage divider string, R24 through R40.</li> </ol>
Inaccurate milliammeter readings.	<ol style="list-style-type: none"> <li>1. Probe switch in wrong position.</li> <li>2. Resistors in voltage divider string, R24 through R34.</li> </ol>
Ohmmeter does not go to zero with leads shorted on RX1 range.	<ol style="list-style-type: none"> <li>1. If ohmmeter reads less than .2 <math>\Omega</math>, this is normal test lead resistance (see Page 37). If ohmmeter reads more than .2 <math>\Omega</math>, refer to "Ohmmeter inoperative or inaccurate readings."</li> </ol>

## MAINTENANCE

### METER

Because of the delicate nature of the meter movement, no attempt should be made to repair the meter. Such attempts would automatically void the standard warranty coverage of the meter itself.

### ELECTROSTATIC CHARGE

The clear plastic meter cover has been treated to resist an accumulation of static electricity. However, should a static charge accumulate through repeated polishing or cleaning of the meter cover, the pointer will deflect in an erratic manner, regardless of whether the instrument is turned off or on. This condition can be corrected quickly. Apply a small quantity of liquid dishwashing detergent to a clean, soft cloth and wipe the surface of the meter cover. The accumulated electrostatic charge will immediately disappear. It is not necessary to remove the cover for this correction.

### CHECKING METER COIL CONTINUITY

If you suspect the meter coil has failed, you can check the continuity of the coil with another ohmmeter as follows. (NOTE: Never check the continuity of the meter coil directly with another ohmmeter. The amount of current that would be

drawn would seriously overload and probably ruin the meter coil.) Always use a limiting resistor with a value of at least 10,000  $\Omega$  in series with the other ohmmeter test leads. The value of the resistor will depend upon the ohmmeter battery voltage and the range on which the ohmmeter is being used. NOTE: If another Heath Solid State VOM Model IM-25 is available, it can be used to check the meter coil directly because of the low voltage and current used.

### TEST LEADS

Because of their constant flexing during use, the test leads are not above suspicion, especially after the VOM has been in use for several years. Erratic or improper DC voltage measurements can sometimes be caused by a fault in the shielded test lead or in the connections in the test probe or phone plug.

### BATTERY REPLACEMENT

In order to replace the 1.5 volt "C" cells, the 2-cell and 12-cell battery holders must be removed from the rear panel. Breakage of the battery holder ends may occur if you attempt to remove them with the battery holder still in place.

## ACCESSORY PROBES

### HIGH VOLTAGE TEST PROBE

A high voltage test probe is available from the Heath Company. This probe will permit the VOM to measure DC up to 30,000 volts, which covers the range of flyback power supply voltages commonly encountered in TV receivers. This probe consists of a red molded housing with a black molded handle. It contains a 2% precision 1090 megohm resistor and provides a DC range multiplication factor of 100 for 11 megohm input voltmeters.

### RF TEST PROBE

An RF test probe is available from the Heath Company. This probe will permit the VOM to be used for RF measurements up to 30 volts; its response is substantially flat from 1000 Hz to 100 MHz. A built-in isolating capacitor permits a DC voltage range of up to 500 volts. It uses a printed circuit board for easy assembly and its housing is of polished aluminum with polystyrene insulation.



## SPECIFICATIONS

### DC VOLTMETER

Nine Ranges. . . . .	0-.15, .5, 1.5, 5, 15, 50, 150, 500, 1500 volts full scale.
Input Resistance. . . . .	11 megohms on all ranges.
Accuracy. . . . .	±3% of full scale.

### DC MILLIAMMETER

Eleven Ranges. . . . .	0-.015, .05, .15, .5, 1.5, 5, 15, 50, 150, 500, 1500 milliamperes full scale.
Insertion Resistance. . . . .	10 K $\Omega$ (.015 ma) to .1 $\Omega$ (1500 ma).
Accuracy. . . . .	±4% of full scale.

### AC VOLTMETER

Nine Ranges. . . . .	0-.15, .5, 1.5, 5, 15, 50, 150, 500, 1500 volts full scale.
Input Resistance. . . . .	10 megohm shunted by 175 pf. (Measured at probe tip.)
Accuracy. . . . .	±5% full scale.
Frequency Response. . . . .	±2 db, 10 Hz-100 kHz.

### AC MILLIAMMETER

Eleven Ranges. . . . .	0-.015, .05, .15, .5, 1.5, 5, 15, 50, 150, 500, 1500 milliamperes full scale.
Insertion Resistance. . . . .	10 K $\Omega$ (.015 ma) to .1 $\Omega$ (1500 ma).
Accuracy. . . . .	±5% full scale.

### OHMMETER

Seven Ranges. . . . .	X1 (10 $\Omega$ center scale), X10, X100, X1K, X10K, X100K, X1 megohm.
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## POWER SUPPLIES

Ohms Circuit. . . . .	3 volts (two C cells).
Ohms Circuit Bias. . . . .	1.35 volt Mercury cell. NEDA 1100 (Eveready E1N).
Amplifier Circuit. . . . .	18 volts, from either of the following sources:
Batteries. . . . .	Twelve C cells;
Power Line. . . . .	120 or 240 volts, 50/60 Hz AC.

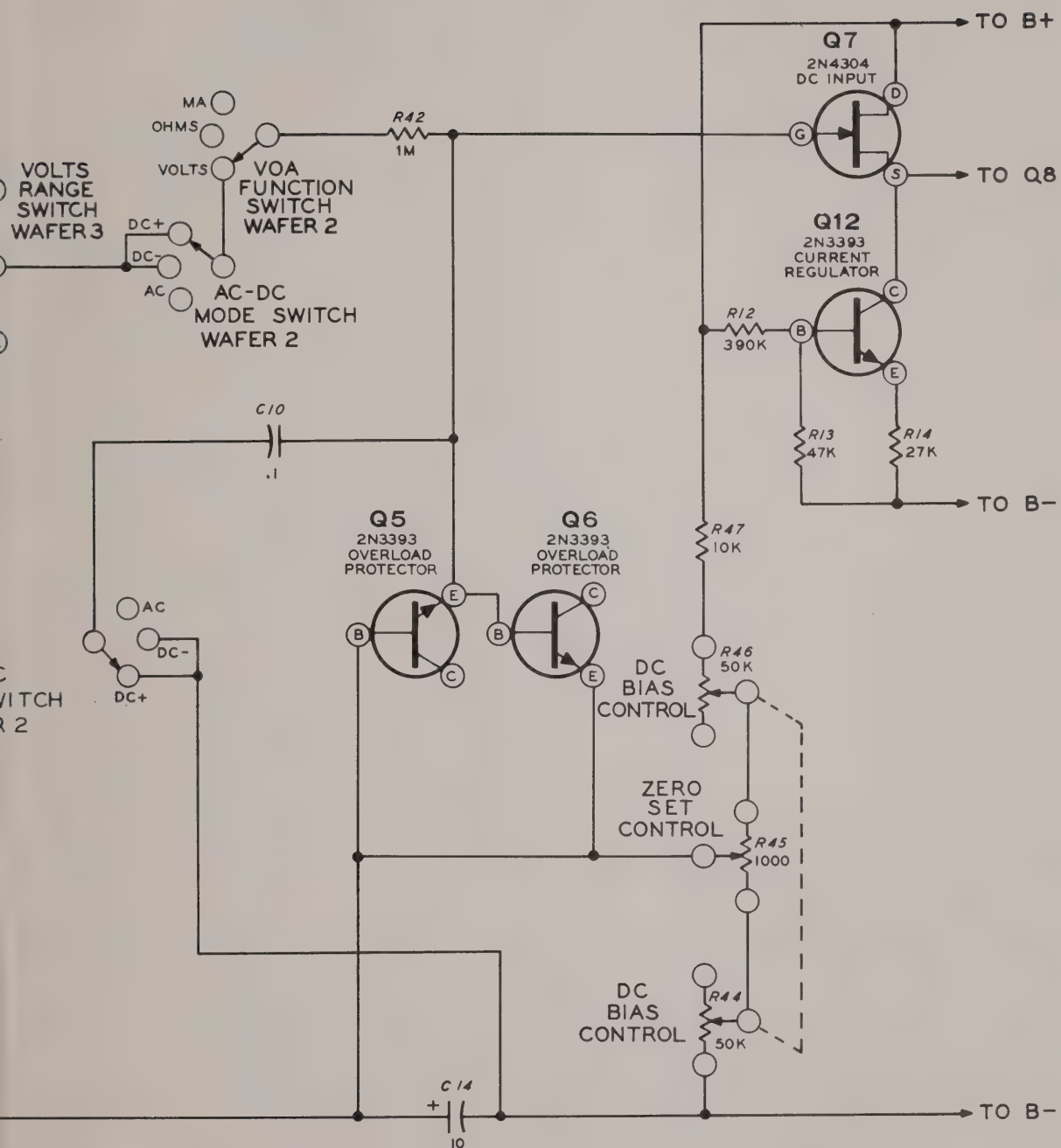
## GENERAL

Probe. . . . .	AC-OHMS/DC switch in probe. Single jack input for probe and ground connections. Circuit ground isolated from cabinet.
Voltage Dividers. . . . .	1 percent precision resistors.
Meter. . . . .	6", 200 $\mu$ a, 100 degree movement.
Transistor-Diode Complement. . . . .	2 - 2N4304 FET transistors. 13- 2N3393 silicon transistors. 1 - 9.1 volt zener diode. 1 - 13 volt zener diode. 4 - 1N191 crystal diode. 1 - Silicon diode.
Color. . . . .	Beige, velvet finish.
Dimensions. . . . .	13-1/2" long x 6-1/4" deep x 5-1/8" high.
Net Weight. . . . .	9 lbs (with batteries installed).

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The Heath Company reserves the right to discontinue instruments and to change specifications at any time without incurring any obligation to incorporate new features in instruments previously sold.





RE 10

## POWER SUPPLIES

Ohms Circuit. . . . .	3 volts (two C cells).
Ohms Circuit Bias. . . . .	1.35 volt Mercury cell, NEDA 1100 (Eveready E1N).
Amplifier Circuit. . . . .	18 volts, from either of the following sources:
Batteries. . . . .	Twelve C cells;
Power Line. . . . .	120 or 240 volts, 50/60 Hz AC.

## GENERAL

Probe. . . . .	AC-OHMS/DC switch in probe. Single jack input for probe and ground connections. Circuit ground isolated from cabinet.
Voltage Dividers. . . . .	1 percent precision resistors.
Meter. . . . .	6", 200 $\mu$ a, 100 degree movement.
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Net Weight. . . . .	9 lbs (with batteries installed).

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# CIRCUIT DESCRIPTION

For a more complete understanding of the circuit, refer to the Schematic Diagram (fold-out from Page 63) while you read the following description. Several partial schematics are also provided to help explain individual circuits.

## GENERAL

The Solid State VOM, and this Circuit Description, consists of the following five major sections:

1. Probe.
2. Four input circuits.
3. Amplifier.
4. Output.
5. Power supply.

The left half of the Schematic Diagram shows the input switching that selects the function, AC or DC mode, and range for measuring different values of AC or DC voltage, AC or DC current, or resistance. The divider and attenuator circuits that are selected by the input switches determine how much voltage, current, or resistance, is required at the probe input to drive the amplifier circuits and deflect the meter pointer.

The right half of the Schematic shows the amplifier circuits, meter rectifier and meter circuits, and the output sections of the function and AC-DC mode switches. At the lower right on the Schematic are the power supply and regulator circuits.

As you read this Circuit Description, keep in mind that the ultimate purpose of the switching, dividing, and attenuating done in the circuits shown on the left half of the Schematic is to provide the proper input voltage (about .15 volt for full scale meter deflection) to the amplifier circuits shown on the right half of the Schematic.

Each individual circuit will be described in the following sections.

## PROBE

The combination AC-Ohms/DC probe contains a switch and a one megohm precision resistor. In the DC position of the switch, the one megohm resistor, R1, is connected in series between the test probe tip and the input jack of the VOM to reduce the loading of the circuits under test. In the AC-Ohms position, the switch shorts resistor R1, eliminating it from the circuit. The test probe is connected through the input jack directly to the rotor of the VOA Function switch.

## INPUT CIRCUITS

### DC Input Circuit (Figure 10)

When the probe, the VOA Function, and the AC-DC Mode switches are set to measure DC Volts, the input voltage is applied from the probe to a voltage divider network that consists of resistors R24 through R40. From the voltage divider, the input voltage (or a portion of it) is coupled through wafer 3 of the Volts Range switch, through sections of the Mode and Function switches, and through resistor R42 to transistor Q7, which is the input of the amplifier. C10 is connected to B- through wafer 2 of the AC-DC mode switch. This provides transient protection for Q7.

The total resistance of the divider network is fixed at 10 megohms. If, for example, the Range switch is in the 1500 position, the resistance between the tap and ground is 1000 ohms. This is a ratio of 10,000 to 1. The applied voltage is divided in the same ratio, so that 1500 volts applied across the divider appears as one ten-thousandth of 1500, or .15 volt, at the 1500 tap.

Remember that only .15 volt is required at the input of the amplifier to produce a full-scale deflection on the meter. Thus, any applied voltage of more than .15 volt must be reduced through the voltage divider network. Operation of the amplifier and meter circuits will be described later.

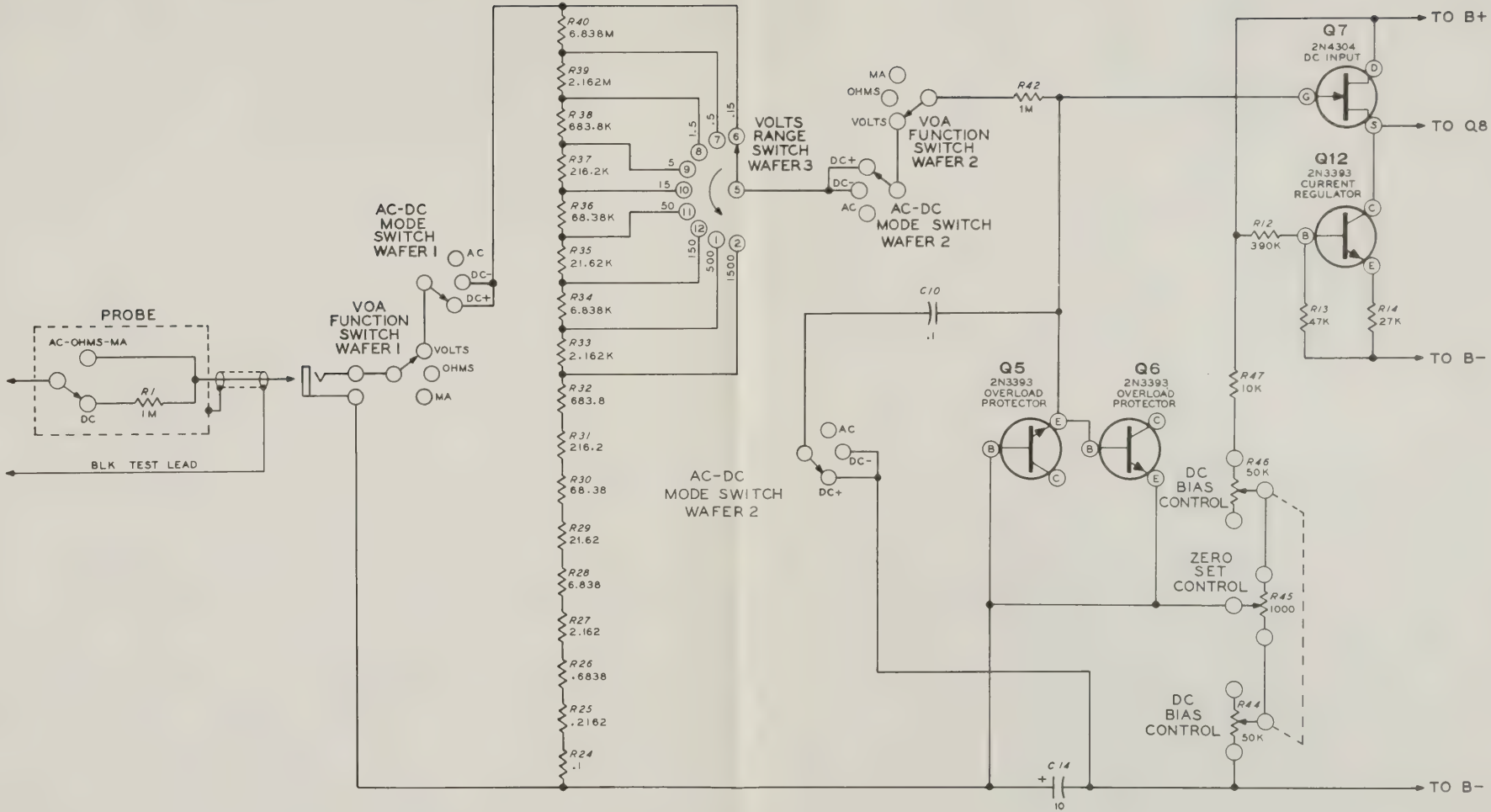


FIGURE 10

### AC Input Circuit (Figure 11)

In the AC position of the probe, VOA Function, and AC-DC Mode switches, the AC voltage being measured is coupled through capacitor C1 to the AC attenuator circuit. The overall attenuator consists of an input voltage divider, transistors Q1, Q2, and Q3, and an output voltage divider.

When the Volts Range switch is in either of the three lowest positions (.15, .5, or 1.5) the applied voltage is not attenuated by the input voltage divider. Rather, it is passed through wafer 2 of the VOA Function switch, and the combination of R5 and C6, to the gate of transistor Q1.

Transistor Q1 is used as a source (S) follower to provide a high impedance input circuit for the AC attenuator section of the VOM. This minimizes undue loading on AC circuits being tested. AC voltages up to 1.5 volts, passed through transistor Q1 and capacitor C9, reach the output voltage divider and wafer 2 of the Volts Range switch.

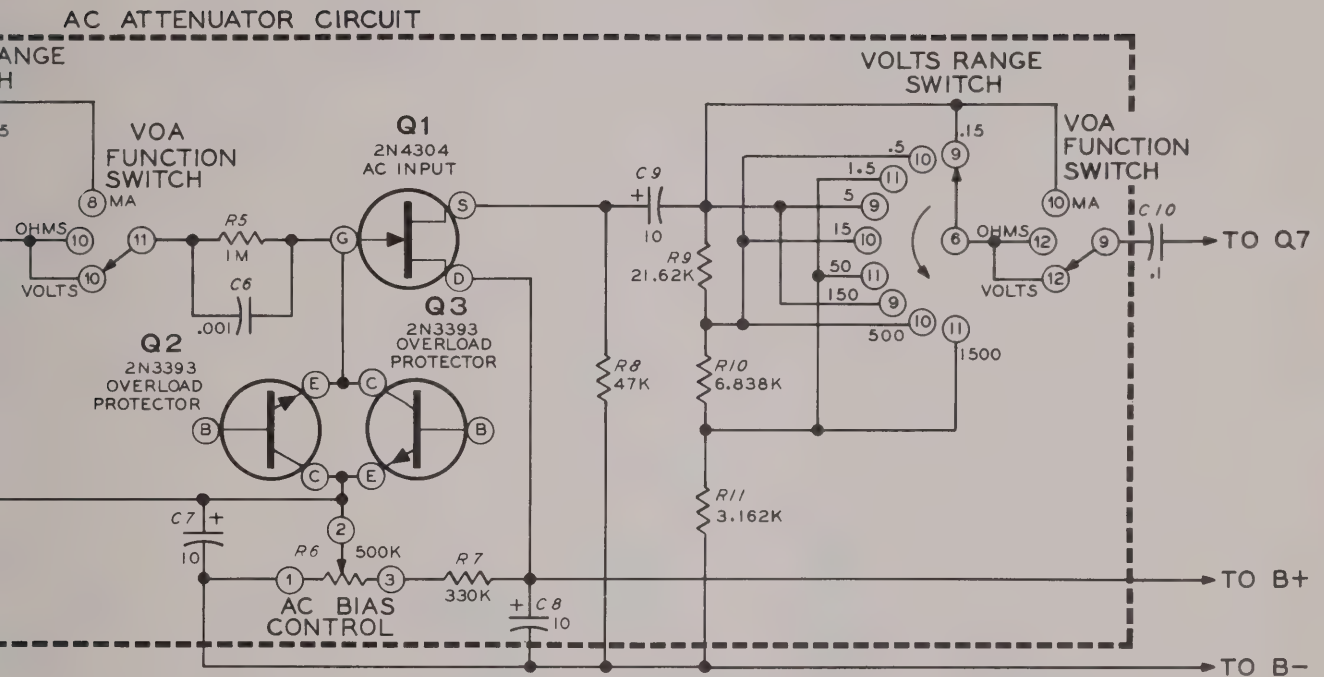
In the .15 position of the Volts Range switch, the output voltage divider does not attenuate the voltage. This is because .15 volt is needed at the amplifier input (transistor Q7) to give a full-scale reading on the meter.

In the .5 and 1.5 positions of the Range switch, only the output voltage divider attenuates the applied voltage either 3.16 to 1 (10 dB) or 10 to 1 (20 dB). For the 5, 15, and 50 volt positions of the switch, the input voltage divider attenuates the voltage 31.6 to 1 (30 dB), and the output voltage divider either provides no attenuation, 3.16 to 1, or 10 to 1 attenuation.

When the Range switch is in the 150, 500, or 1500 volt positions, the input voltage divider attenuates 1000 to 1 (60 dB). The output voltage divider again provides either no attenuation, 3.16 to 1, or 10 to 1 attenuation.

The AC Attenuation Chart shows the Volts Range switch positions, and the amount of attenuation provided by the input and output voltage dividers.





RE 11

### AC Input Circuit (Figure 11)

In the AC position of the probe, VOA Function, and AC-DC Mode switches, the AC voltage being measured is coupled through capacitor C1 to the AC attenuator circuit. The overall attenuator consists of an input voltage divider, transistors Q1, Q2, and Q3, and an output voltage divider.

When the Volts Range switch is in either of the three lowest positions (.15, .5, or 1.5) the applied voltage is not attenuated by the input voltage divider. Rather, it is passed through wafer 2 of the VOA Function switch, and the combination of R5 and C6, to the gate of transistor Q1.

Transistor Q1 is used as a source (S) follower to provide a high impedance input circuit for the AC attenuator section of the VOM. This minimizes undue loading on AC circuits being tested. AC voltages up to 1.5 volts, passed through transistor Q1 and capacitor C9, reach the output voltage divider and wafer 2 of the Volts Range switch.

In the .15 position of the Volts Range switch, the output voltage divider does not attenuate the voltage. This is because .15 volt is needed at the amplifier input (transistor Q7) to give a full-scale reading on the meter.

In the .5 and 1.5 positions of the Range switch, only the output voltage divider attenuates the applied voltage either 3.16 to 1 (10 dB) or 10 to 1 (20 dB). For the 5, 15, and 50 volt positions of the switch, the input voltage divider attenuates the voltage 31.6 to 1 (30 dB), and the output voltage divider either provides no attenuation, 3.16 to 1, or 10 to 1 attenuation.

When the Range switch is in the 150, 500, or 1500 volt positions, the input voltage divider attenuates 1000 to 1 (60 dB). The output voltage divider again provides either no attenuation, 3.16 to 1, or 10 to 1 attenuation.

The AC Attenuation Chart shows the Volts Range switch positions, and the amount of attenuation provided by the input and output voltage dividers.



In this Chart, the Volts Range switch column lists the voltage that must be applied to the test probe, in each switch position, to provide a full-scale indication on the meter.

VOLTS RANGE SWITCH	INPUT DIVIDER ATTENUATOR	VOLTS THROUGH TRANSISTOR Q1 (APPROX.)*	OUTPUT DIVIDER ATTENUATION	VOLTS TO TRANSISTOR Q7 (APPROX.)*
.15	0	.15	0	.15
.5	0	.5	3,16 to 1	.15
1.5	0	1.5	10 to 1	.15
5	31,6 to 1	.15	0	.15
15	31,6 to 1	.5	3,16 to 1	.15
50	31,6 to 1	1.5	10 to 1	.15
150	1000 to 1	.15	0	.15
500	1000 to 1	.5	3,16 to 1	.15
1500	1000 to 1	1.5	10 to 1	.15

\*The voltages tabulated for Q1 and Q7 are approximate, because the full-scale markings for the two scales do not coincide. Attenuation is in steps of 10 dB.

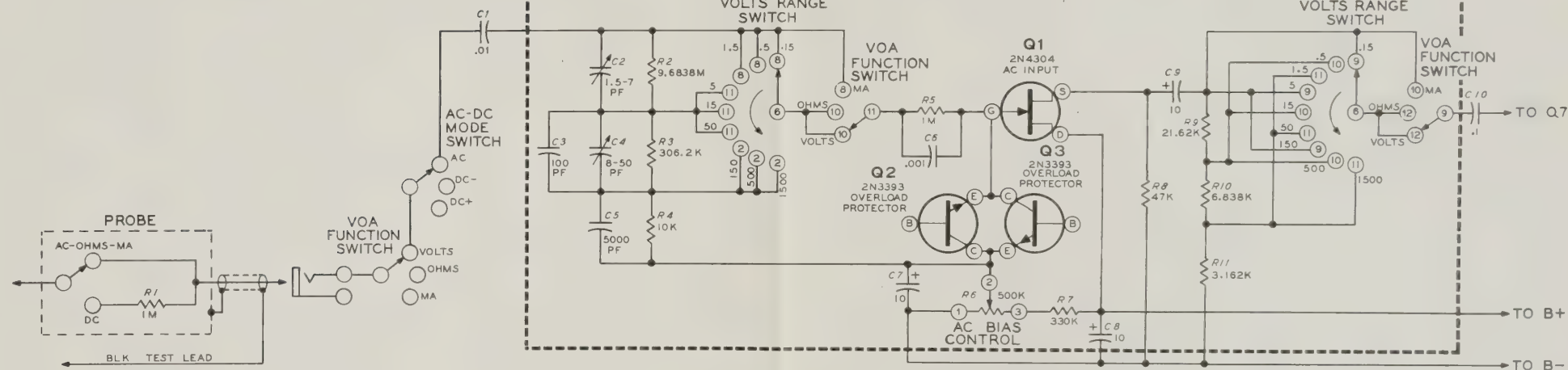


FIGURE 11

The test probe, cable, and input circuits all exhibit some capacitive characteristics that could result in inaccurate meter readings at certain frequencies, or on certain Volts ranges. (AC voltages with frequencies up to 100 kHz can be measured on this VOM.) Capacitors C2 through C5 are in the input voltage divider circuit to compensate for these capacitive effects in the input circuit. Capacitors C2 and C4 are trimmer capacitors that are adjusted in the 5 to 50 and 150 to 1500 volt ranges respectively.

Resistor R5 and transistors Q2 and Q3 (used as Zener diodes) provide overload protection for transistor Q1. If the AC voltage at the gate of Q1 exceeds the 9 volt level determined by the Zener diode action of Q2 and Q3, these transistors will conduct on alternate half cycles. This limits the voltage at the gate of transistor Q1 and protects it from damage.

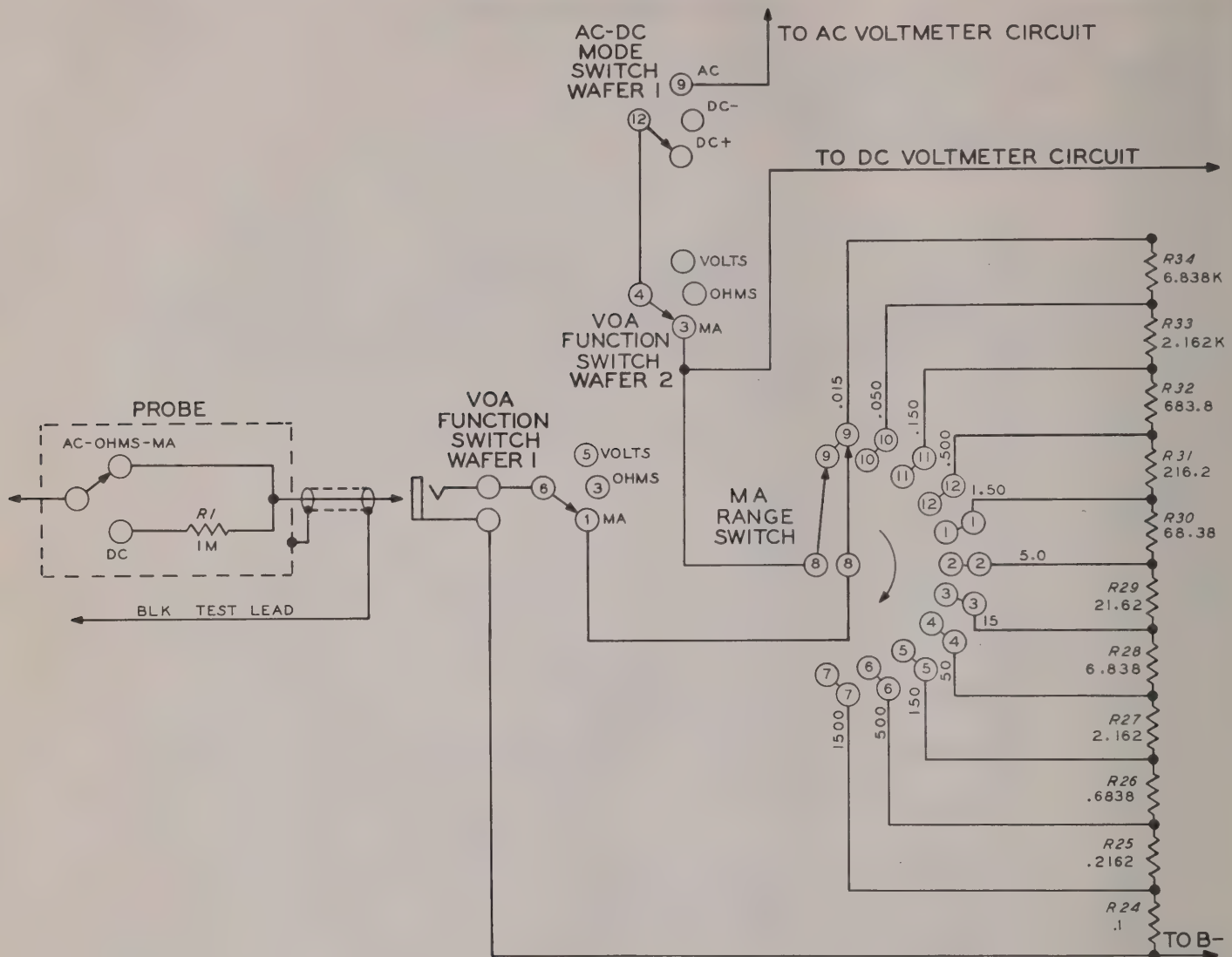


Figure 12

### Milliampere Input Circuit (Figure 12)

DC or AC current measurements of from .015 milliampere to 1500 milliampere (1.5 ampere) can be made with the Solid State VOM. This is done by passing the current through a resistance of known value and measuring the voltage drop across it.

The MA Range switch selects a resistor, or series of resistors (R24 through R34) and connects it across the test probe input. When the test probe and common lead are connected in series with the circuit to be tested, current flowing through the

known resistance causes a voltage drop across it. This voltage drop is measured by the voltmeter circuit. Figure 12A shows a simplified example and the application of Ohms Law.

In conjunction with the MA Range resistors, the DC voltmeter circuit is used for measuring DC currents, and the AC voltmeter circuit is used for measuring AC currents. The AC-DC Mode switch connects either of the voltmeter circuits for AC or DC current measurements. The test probe switch must be in the AC/OHMS position when measuring either AC or DC current.

### Ohmmeter Input Circuit (Figure 13)

The voltage required to operate the ohmmeter circuit is supplied by battery E2 through constant current source Q4. To make the explanation of the ohmmeter operation simpler, assume that the Ohms Range switch is in the RX1 position.

Transistor Q4 is biased by 1.35 volt mercury battery E3 to produce a constant current of approximately 7 ma through resistor R43. This 7 ma, flowing through resistors R24-R28 (a total of 10  $\Omega$ ), results in approximately .07 volts across these resistors.

The .07 volts is then coupled through the OHMS Range switch to the gate of transistor Q7, which is the input of the amplifier section. With the VOA Function switch in the Ohms position, the Ohms Calibrate control in the amplifier circuit is adjusted so this voltage that is applied to Q7 causes a full-scale deflection of the meter.

When an external resistance of 10 ohms, for example, is placed in parallel with R24-R28, by connecting it between the test probe and common lead, the resulting resistance of the circuit is 5 ohms. Since the current is held constant at .007 amperes, the voltage drop across the 5 ohms is  $.007 \times 5$ , or .035 volts.

This is one half the voltage required at Q7 for full scale meter deflection, so the meter reads half scale, which is the 10  $\Omega$  indication.

For other positions of the OHMS Range switch, resistors are inserted between the .07 volt source and the Range switch. Since no current flows through these resistors without an external resistance connected, the full .07 volts is applied to transistor Q7 and keeps the Meter at full scale on all ranges. If the OHMS Range switch is in the RX1 Meg position, for example, all resistors from R29 through R40 (a total of 10 megohms) are placed in series with the .07 volt source and the Range switch. Now, assume that an external resistance of 10 megohms is placed between the test probe and common lead. The 10 megohms of the internal resistors and the 10 megohms external resistance form a voltage divider for the .07 volts. The rotor of the switch is at the tap of the voltage divider and is connected to transistor Q7; thus the voltage applied to Q7 is reduced proportionately. In this case, .035 volts is applied to Q7 and causes the meter to read half scale or 10 (10 megohms).

The internal (standard) resistance is connected into the circuit in series with the resistance being measured. The maximum voltage which

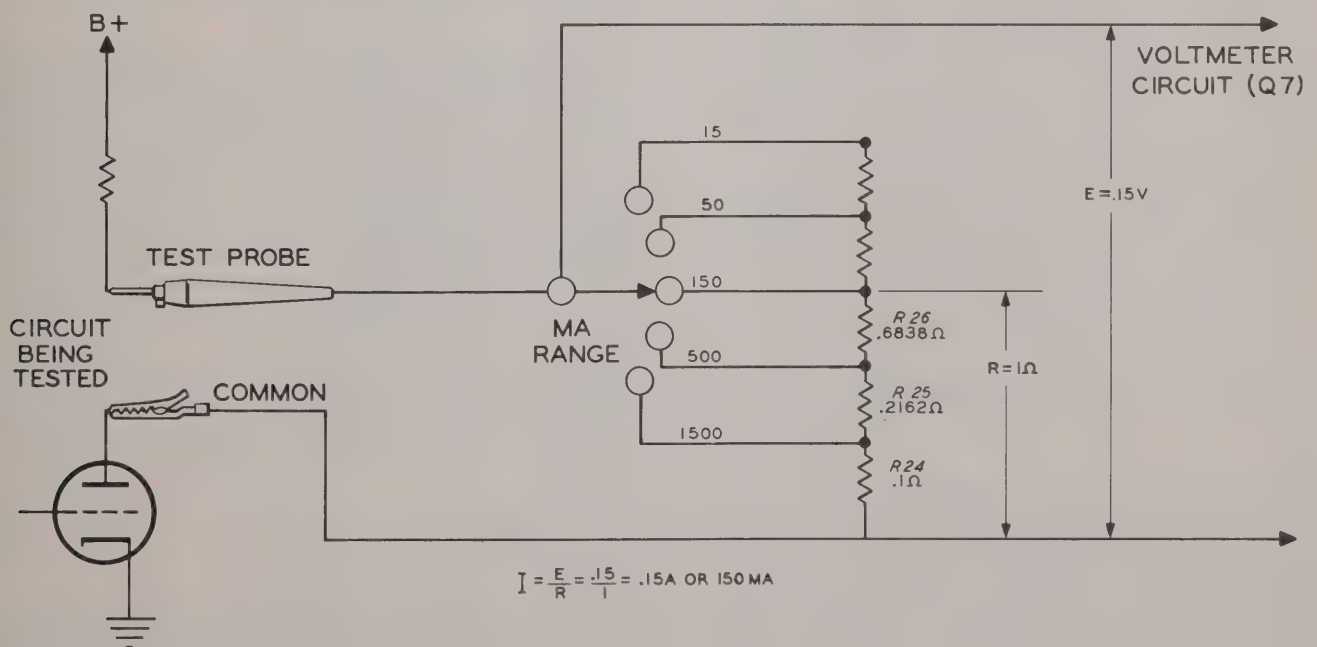


Figure 12A



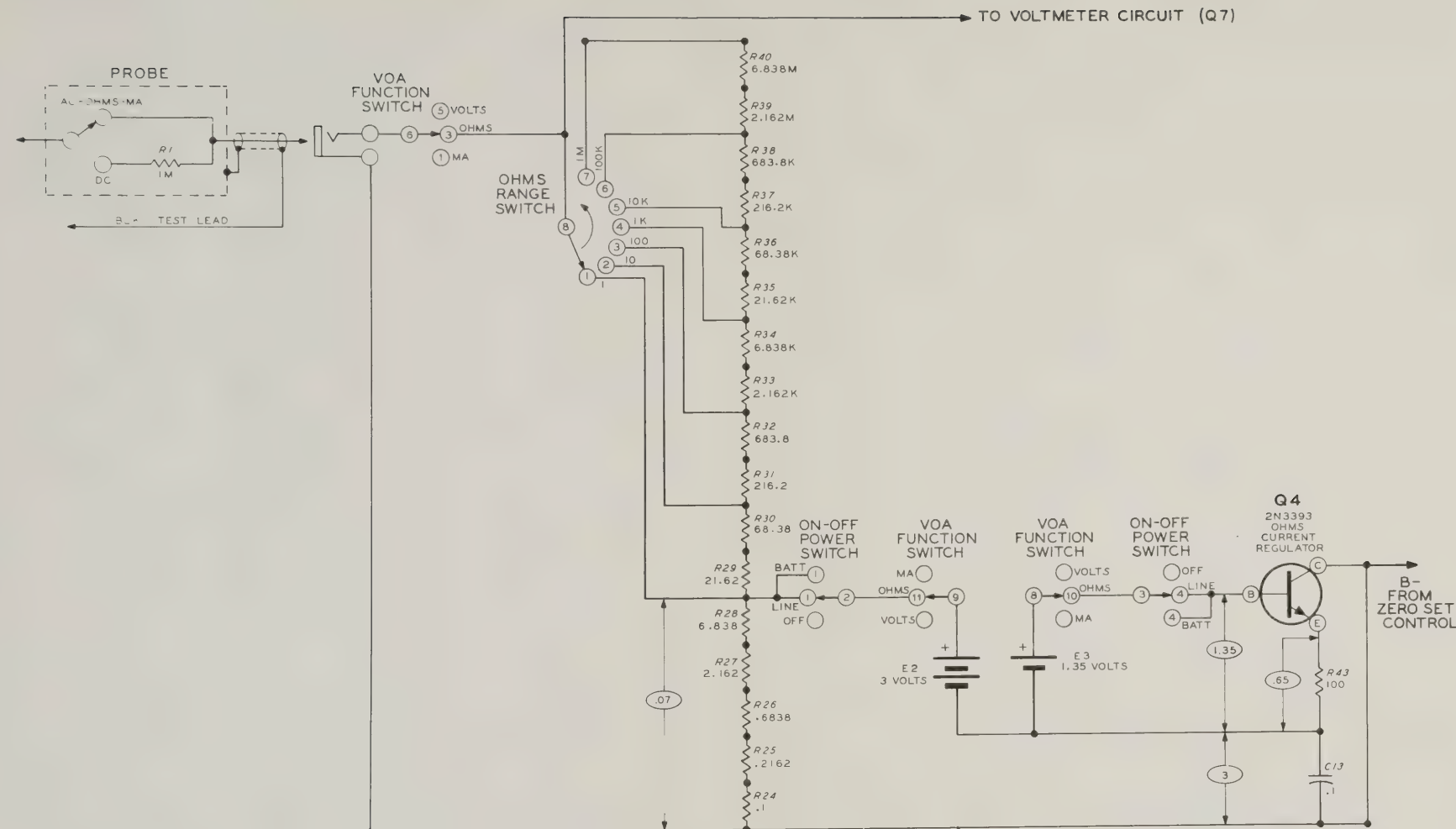


FIGURE 13

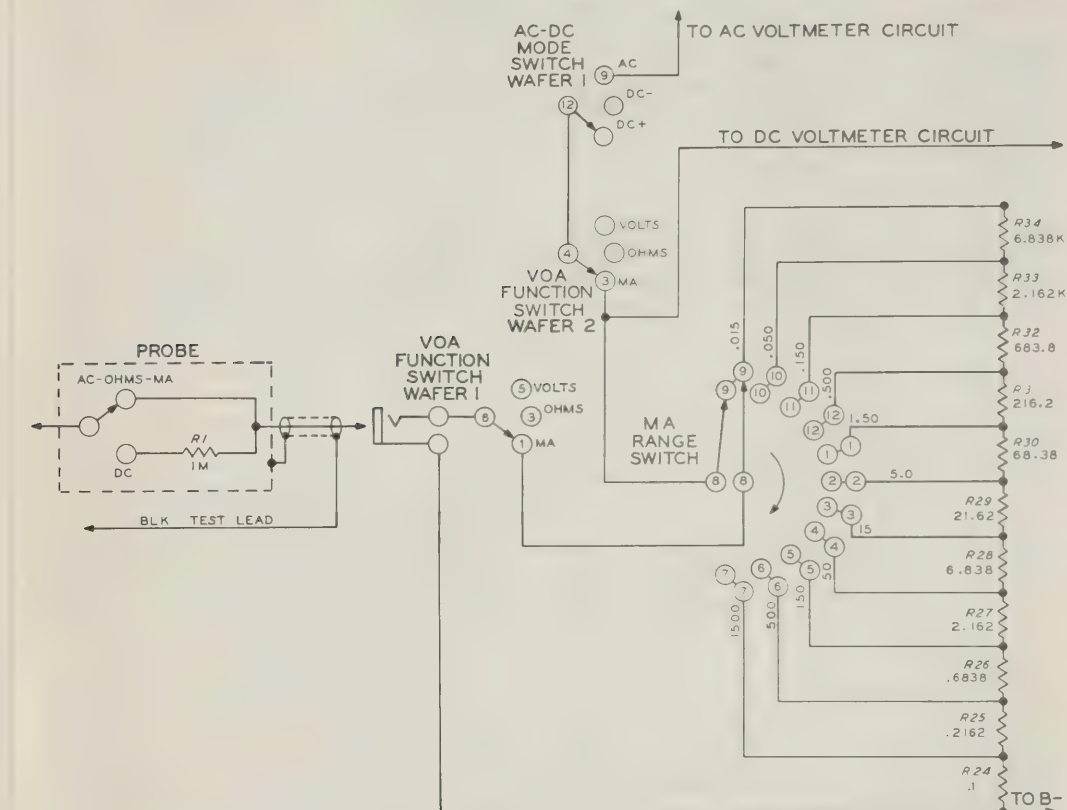


Figure 12

### Milliampere Input Circuit (Figure 12)

DC or AC current measurements of from .015 milliamperes to 1500 milliamperes (1.5 ampere) can be made with the Solid State VOM. This is done by passing the current through a resistance of known value and measuring the voltage drop across it.

The MA Range switch selects a resistor, or series of resistors (R24 through R34) and connects it across the test probe input. When the test probe and common lead are connected in series with the circuit to be tested, current flowing through the

known resistance causes a voltage drop across it. This voltage drop is measured by the voltmeter circuit. Figure 12A shows a simplified example and the application of Ohms Law.

In conjunction with the MA Range resistors, the DC voltmeter circuit is used for measuring DC currents, and the AC voltmeter circuit is used for measuring AC currents. The AC-DC Mode switch connects either of the voltmeter circuits for AC or DC current measurements. The test probe switch must be in the AC/OHMS position when measuring either AC or DC current.

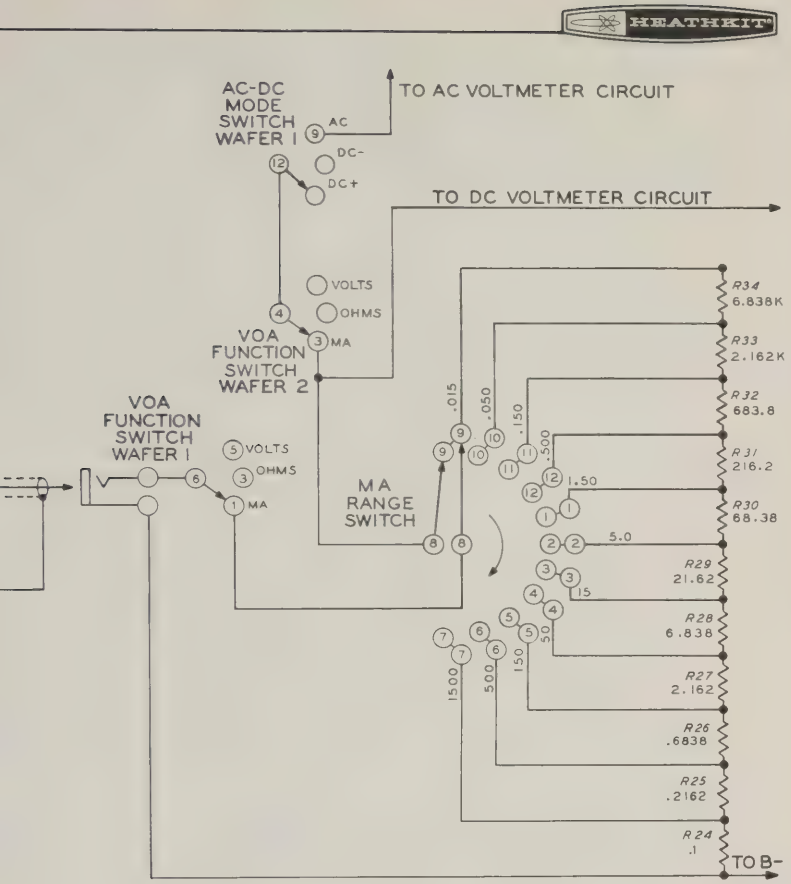


Figure 12

...it (Figure 12)  
...measurements of from .015  
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The .07 volts is then coupled through the OHMS Range switch to the gate of transistor Q7, which is the input of the amplifier section. With the VOA Function switch in the Ohms position, the Ohms Calibrate control in the amplifier circuit is adjusted so this voltage that is applied to Q7 causes a full-scale deflection of the meter.

When an external resistance of 10 ohms, for example, is placed in parallel with R24-R28, by connecting it between the test probe and common lead, the resulting resistance of the circuit is 5 ohms. Since the current is held constant at .007 amperes, the voltage drop across the 5 ohms is .007 x 5, or .035 volts.

This is one half the voltage required at Q7 for full scale meter deflection, so the meter reads half scale, which is the 10  $\Omega$  indication.

For other positions of the OHMS Range switch, resistors are inserted between the .07 volt source and the Range switch. Since no current flows through these resistors without an external resistance connected, the full .07 volts is applied to transistor Q7 and keeps the Meter at full scale on all ranges. If the OHMS Range switch is in the RX1 Meg position, for example, all resistors from R29 through R40 (a total of 10 megohms) are placed in series with the .07 volt source and the Range switch. Now, assume that an external resistance of 10 megohms is placed between the test probe and common lead. The 10 megohms of the internal resistors and the 10 megohms external resistance form a voltage divider for the .07 volts. The rotor of the switch is at the tap of the voltage divider and is connected to transistor Q7; thus the voltage applied to Q7 is reduced proportionately. In this case, .035 volts is applied to Q7 and causes the meter to read half scale or 10 (10 megohms).

The internal (standard) resistance is connected into the circuit in series with the resistance being measured. The maximum voltage which

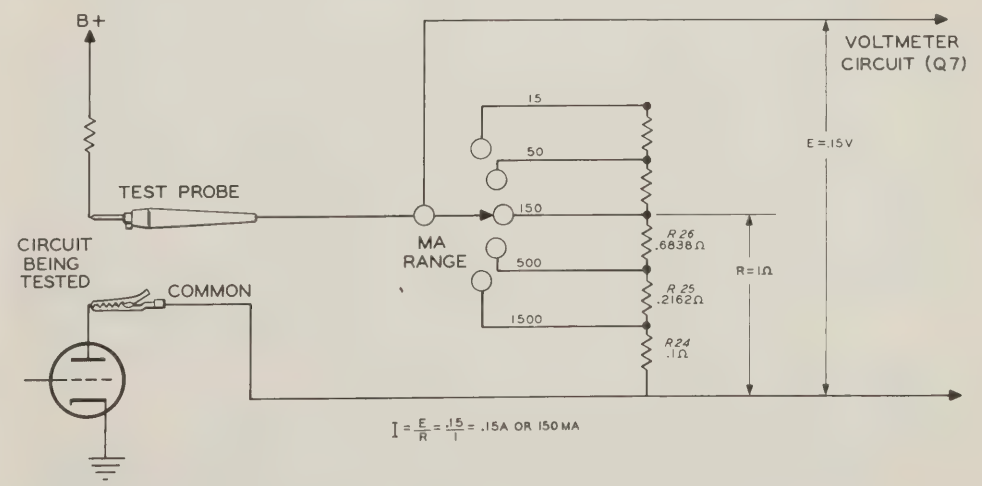


Figure 12A

could be applied to a test component is approximately 70 millivolts and the maximum current through it is approximately 7 milliamperes. This low voltage and current is a definite advantage when checking components in a transistor circuit, since a silicon junction will not begin to conduct at this low voltage and disrupt the resistance reading. But, for this reason, forward-to-reverse resistance ratios in diodes cannot be measured with this instrument.

### Amplifier Circuit (Figure 14)

The heart of the Solid State VOM is the amplifier and output circuit. The input switching and attenuating that is done in the circuits shown on the left side of the Schematic provide the correct voltage to the amplifier section. Whether AC or DC voltage, resistance, or AC or DC current is being measured, the meter pointer is driven by the voltage applied to amplifier input transistor Q7.

Transistor Q7 is a field effect transistor (FET). This type of transistor is used because it provides the high impedance input that keeps it from loading the input switching and attenuating circuits. A constant current source, transistor Q12, is used in place of a resistor in the source (S) circuit of Q7.

Since the electrical operating characteristics of FET transistors vary widely from one transistor to another, resistors R44, R45, R46, and R47 are used as an adjustable voltage divider network. The dual DC Bias control, R44 and R46, determines the DC voltage range available to bias the gate of Q7. Zero Set control R45 is used as a fine adjustment of the gate bias voltage to provide approximately 4.9 volts at the base of Q8 for a left end zero indication on the meter. The Zero Adjust control is also used to adjust the meter pointer to center scale zero for plus or minus voltage measurements.

Transistors Q5 and Q6, together with resistor R42, are used to protect the amplifier circuit from severe accidental overloads. They accomplish this by limiting the input voltage applied to the gate of Q7 to approximately .6 volts. The excess applied voltage is dropped across resistor R42. Since the source current of transistor Q7 is held constant by transistor

Q12, voltage variations at the gate of Q7 are passed to the base of transistor Q8.

Transistors Q8 and Q11 are connected as a differential, or balanced, amplifier. The base of Q11 is kept biased at approximately 4.9 volts by resistors R22 and R23. To balance the amplifier circuit, 4.9 volts is required at the base of Q8. This voltage is determined by the setting of the dual DC Bias control, R44 and R46, and Zero Set control R45.

The amplifier circuit current is governed by transistor Q13. This transistor acts as a constant current source in the following manner: Transistors Q14 and Q15 are connected as series diodes and form a voltage divider with resistor R48. The voltage at the base of Q13 is determined by the voltage drop across Q14 and Q15 (approximately 1.2 volts) that is caused by the current through R48. With 1.2 volts on the base of Q13, its emitter voltage is approximately .6 volts regardless of the value of resistor R49. Thus, R49 determines the current through Q13. A value of 1500  $\Omega$  for R49 provides approximately 400  $\mu$ a through Q13 to amplifier transistors Q8 and Q11 (200  $\mu$ a each).

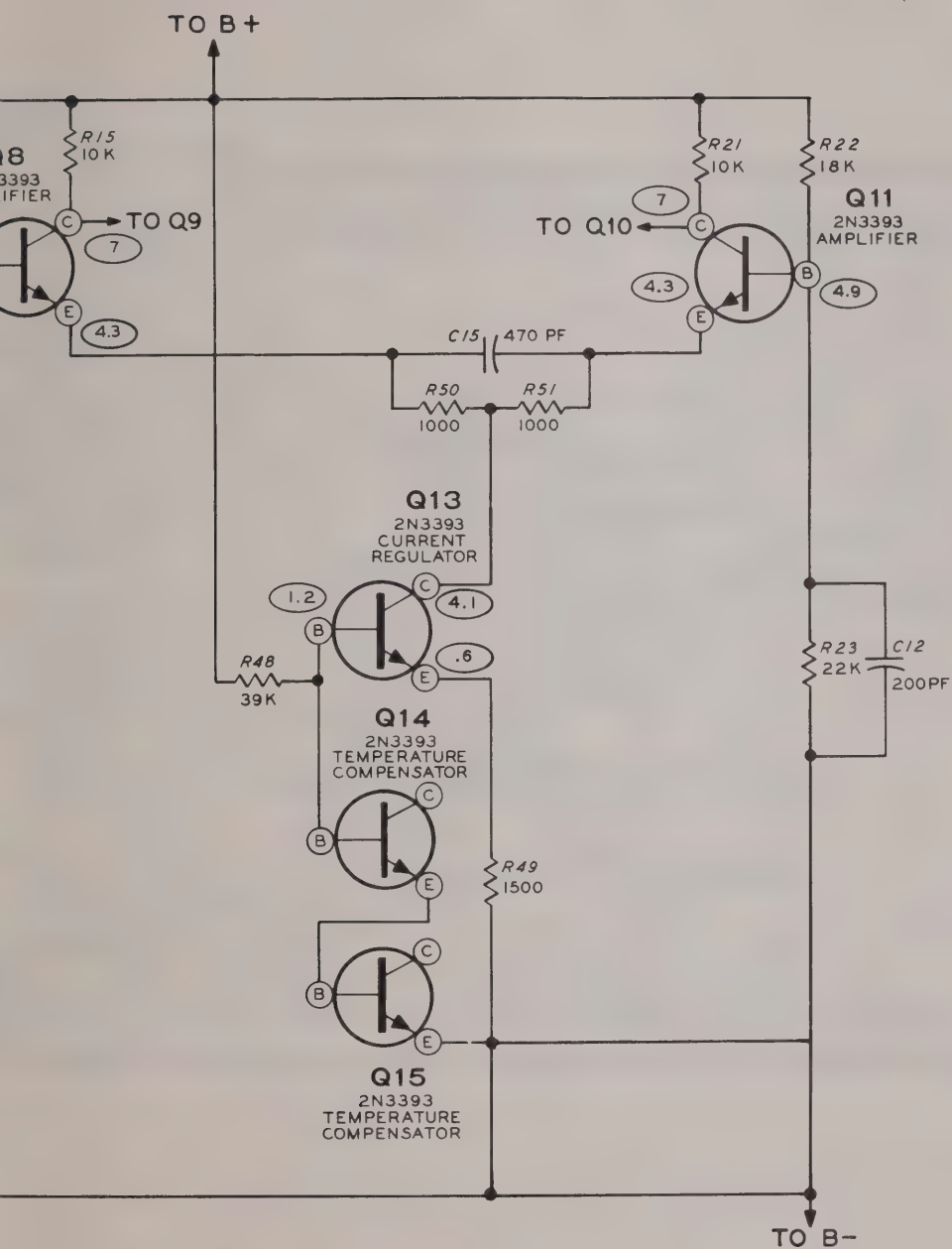
With 4.9 volts on the bases of transistors Q8 and Q11, the 200  $\mu$ a flowing through their collector-emitter circuits produce equal voltages of approximately 7 volts at each of these collectors.

If the input voltage at Q7 becomes more positive, the voltage at the base of Q8 also becomes more positive. This lowers the collector voltage of Q8 and raises the emitter voltage. An emitter-follower action transfers the increased voltage through R50 and R51 to the emitter of Q11. Since the base of Q11 is a constant 4.9 volts, the increased emitter voltage has the same effect on the collector as a decrease in base voltage. That is, the collector voltage is decreased. Thus, an unbalanced, or differential voltage exists between the collectors of Q8 and Q11. The difference voltage is direct-coupled to the bases of output transistors Q9 and Q10.

### OUTPUT CIRCUIT (Figure 15)

For DC measurements, the meter is connected directly to the emitters of emitter follower transistors Q9 and Q10. Since the bases of Q9 and Q10 are directly coupled to the collectors





could be applied to a test component is approximately 70 millivolts and the maximum current through it is approximately 7 milliamperes. This low voltage and current is a definite advantage when checking components in a transistor circuit, since a silicon junction will not begin to conduct at this low voltage and disrupt the resistance reading. But, for this reason, forward-to-reverse resistance ratios in diodes cannot be measured with this instrument.

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Transistors Q5 and Q6, together with resistor R42, are used to protect the amplifier circuit from severe accidental overloads. They accomplish this by limiting the input voltage applied to the gate of Q7 to approximately .6 volts. The excess applied voltage is dropped across resistor R42. Since the source current of transistor Q7 is held constant by transistor

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Transistors Q8 and Q11 are connected as a differential, or balanced, amplifier. The base of Q11 is kept biased at approximately 4.9 volts by resistors R22 and R23. To balance the amplifier circuit, 4.9 volts is required at the base of Q8. This voltage is determined by the setting of the dual DC Bias control, R44 and R46, and Zero Set control R45.

The amplifier circuit current is governed by transistor Q13. This transistor acts as a constant current source in the following manner: Transistors Q14 and Q15 are connected as series diodes and form a voltage divider with resistor R48. The voltage at the base of Q13 is determined by the voltage drop across Q14 and Q15 (approximately 1.2 volts) that is caused by the current through R48. With 1.2 volts on the base of Q13, its emitter voltage is approximately .6 volts regardless of the value of resistor R49. Thus, R49 determines the current through Q13. A value of 1500  $\Omega$  for R49 provides approximately 400  $\mu$ a through Q13 to amplifier transistors Q8 and Q11 (200  $\mu$ a each).

With 4.9 volts on the bases of transistors Q8 and Q11, the 200  $\mu$ a flowing through their collector-emitter circuits produce equal voltages of approximately 7 volts at each of these collectors.

If the input voltage at Q7 becomes more positive, the voltage at the base of Q8 also becomes more positive. This lowers the collector voltage of Q8 and raises the emitter voltage. An emitter-follower action transfers the increased voltage through R50 and R51 to the emitter of Q11. Since the base of Q11 is a constant 4.9 volts, the increased emitter voltage has the same effect on the collector as a decrease in base voltage. That is, the collector voltage is decreased. Thus, an unbalanced, or differential voltage exists between the collectors of Q8 and Q11. The difference voltage is direct-coupled to the bases of output transistors Q9 and Q10.

### OUTPUT CIRCUIT (Figure 15)

For DC measurements, the meter is connected directly to the emitters of emitter follower transistors Q9 and Q10. Since the bases of Q9 and Q10 are directly coupled to the collectors

of Q8 and Q11, the voltage changes at the collectors of Q8 and Q11 are coupled to the meter terminals. Therefore, when a positive voltage is applied to the amplifier, the emitter voltage of output transistor Q9 decreases, while the emitter voltage of transistor Q10 increases. With the meter connected through the VOA Function switch and the AC-DC Mode switch to the emitters of Q9 and Q10, the meter deflects upscale to indicate the test voltage applied to the probe at the input of the VOM. The amount of voltage required to deflect the meter the proper amount is adjusted by DC calibration control R18.

When the AC voltage measurement function of the VOM is used, the output voltage at the emitter Q9 and Q10 is an AC voltage. Before the meter can indicate this voltage, it must be rectified to produce a DC voltage. The rectification process is done by diodes D1, D2, D3, and D4. These diodes are connected as a bridge rectifier with the meter connected across the output of the bridge. The amount of meter deflection required to represent the AC voltage

applied at the input of the VOM is adjusted by AC Calibration control R17.

The Ohmmeter measurement function of the VOM applies a DC voltage to the base of Q8. Therefore, the circuit reaction of the amplifier and output circuits remains the same as when measuring a DC voltage. The amount of meter deflection required to represent a specific resistance is determined by the adjustment of Ohmmeter Calibration control R20.

POWER SUPPLY

Either of two separate power supplies can be selected with the On-Off Power switch. In the Line position, the power supply uses a dual-primary transformer for operation from either 120 volts or 240 volts, 50-60 Hz. A silicon diode is used in a half-wave rectifier circuit to supply B+ to the VOM. The B+ supply is regulated by two zener diodes to approximately 9 volts. In the Batt position of the On-Off Power switch, a DC supply, consisting of twelve 1-1/2 volt C cells, is connected for portable operation.

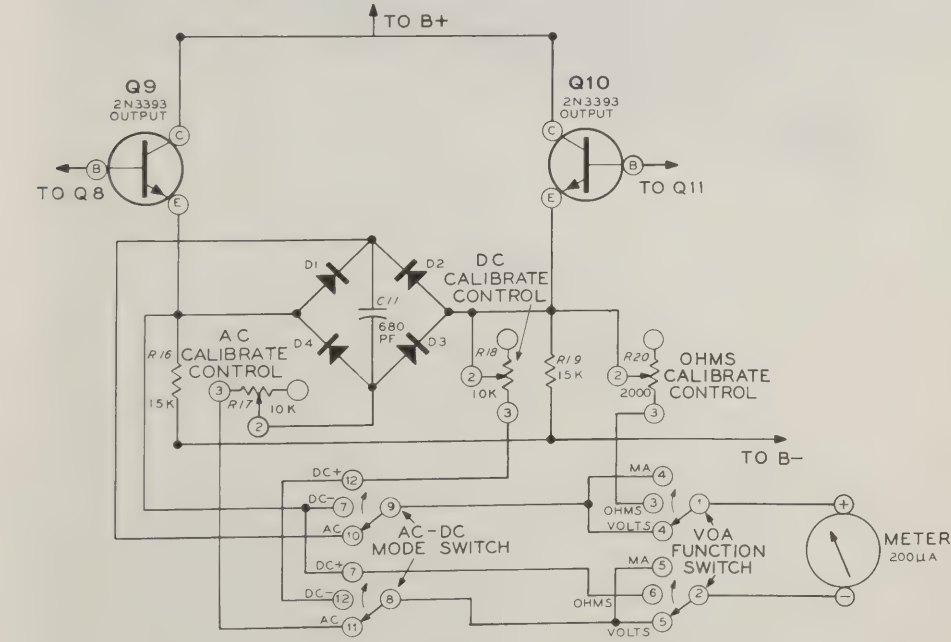


Figure 15

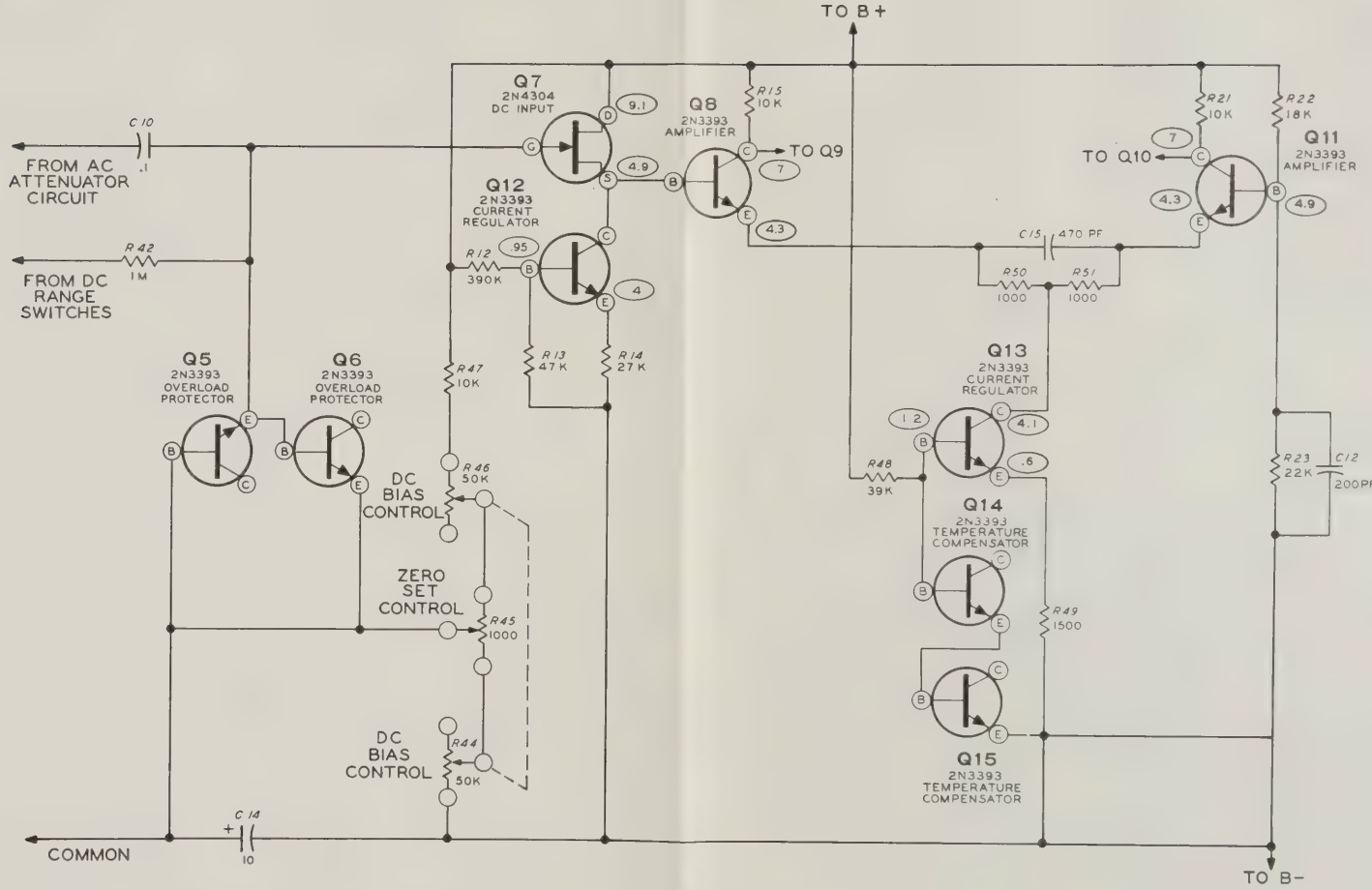
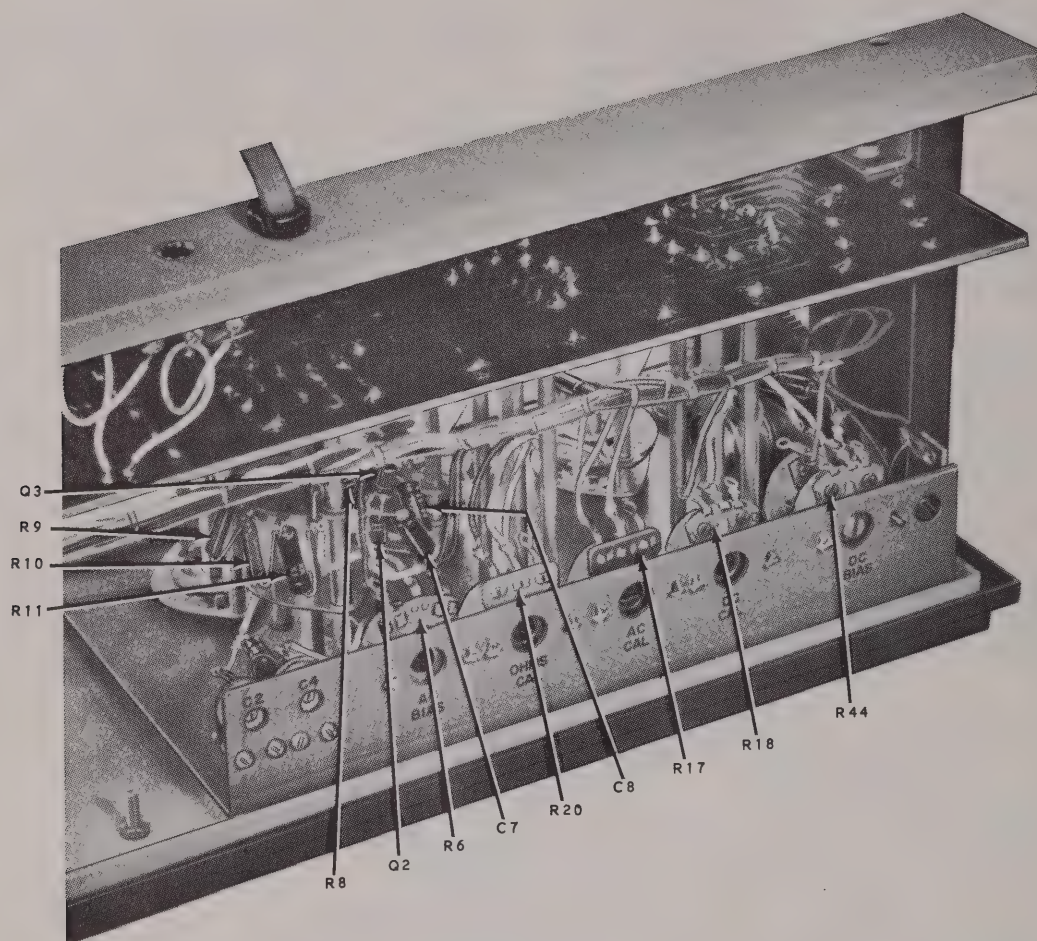


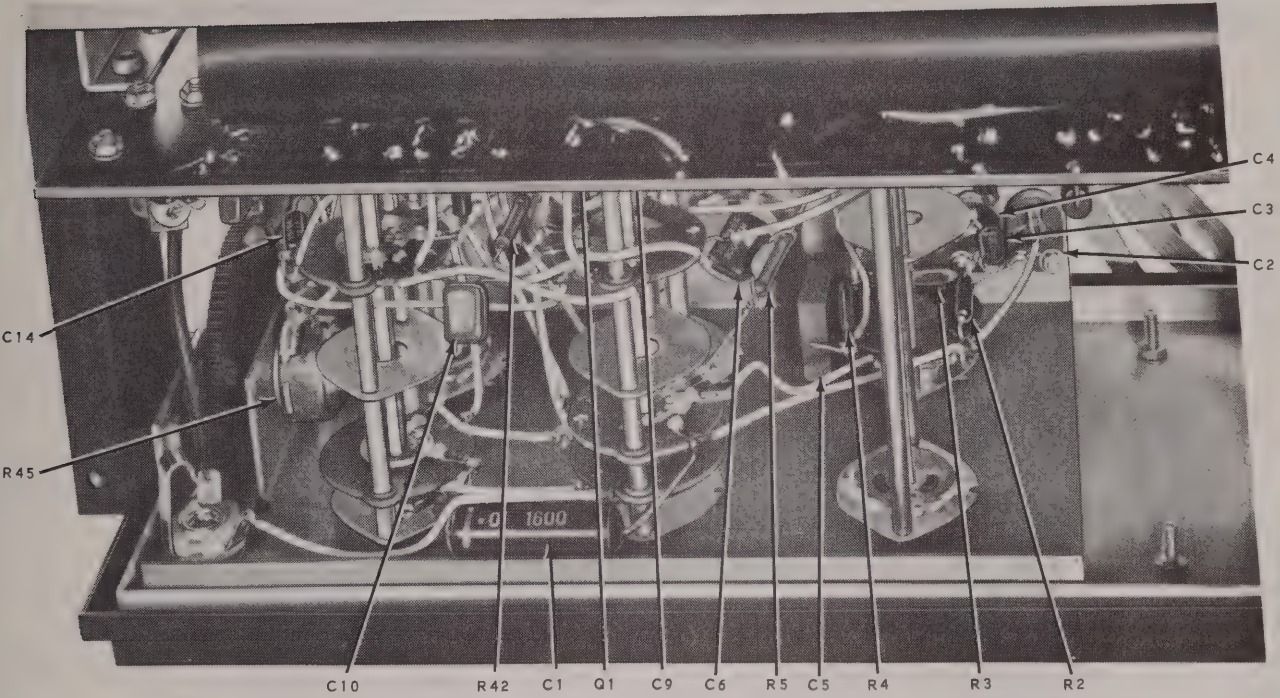
FIGURE 14



# CHASSIS PHOTOGRAPHS



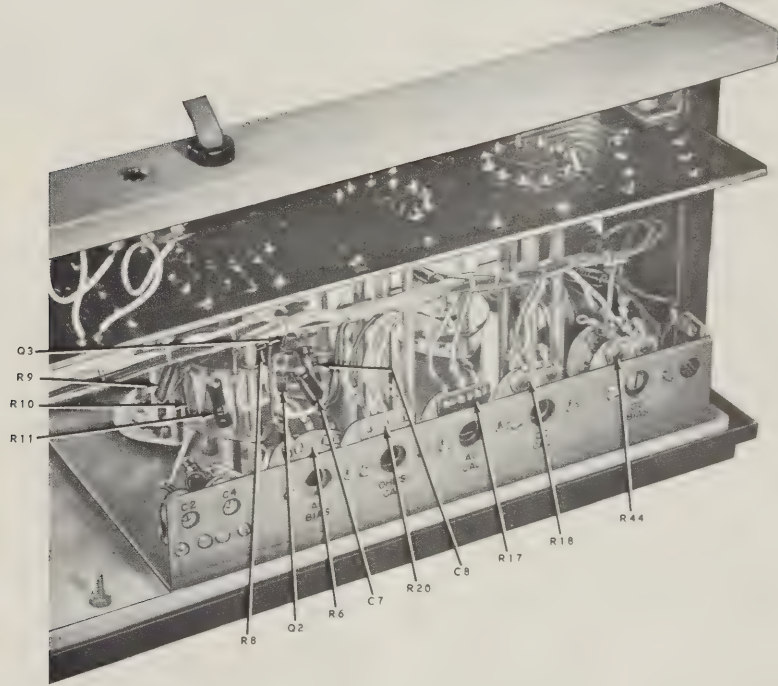
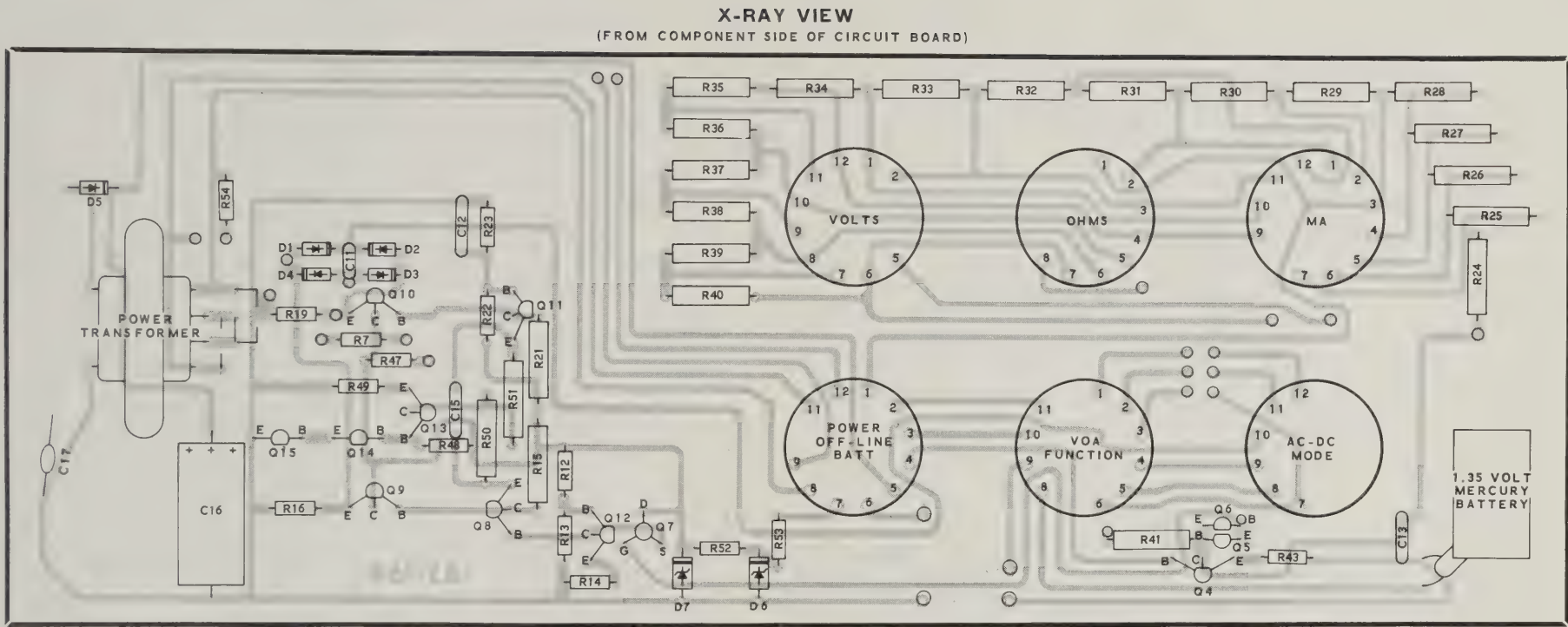
TOP VIEW



BOTTOM VIEW



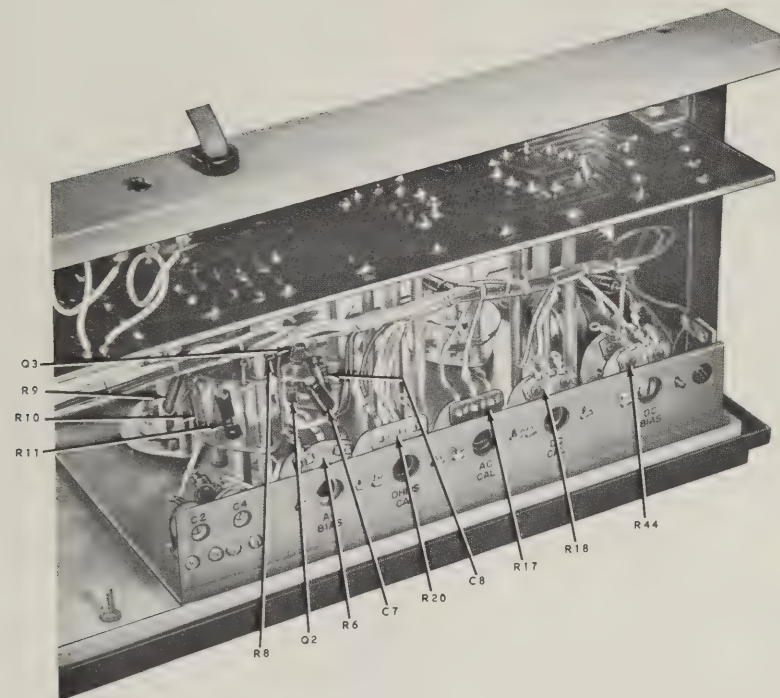
CHASSIS PHOTOGRAPHS



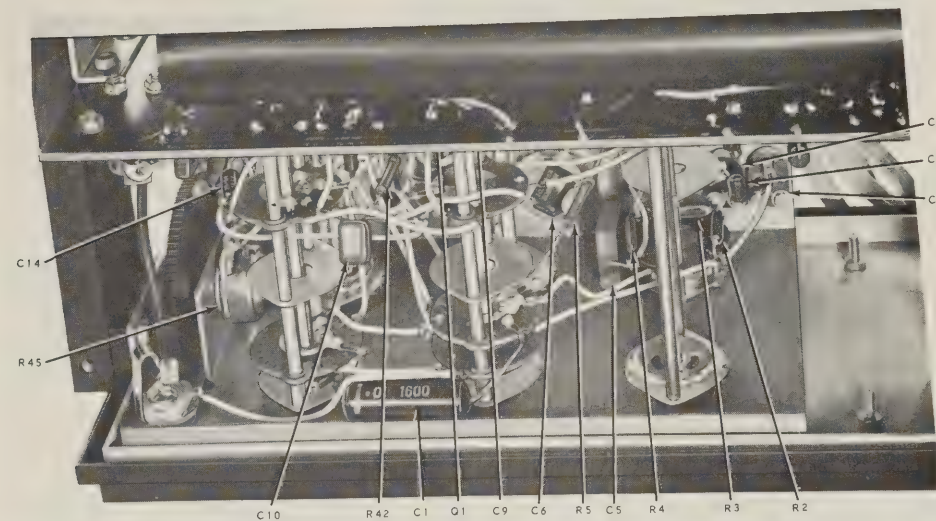
TOP VIEW



## CHASSIS PHOTOGRAPHS



TOP VIEW



BOTTOM VIEW

## REPLACEMENT PARTS PRICE LIST

PART No.	PRICE Each	DESCRIPTION
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### RESISTORS

#### 1/2 Watt

1-3	.10	100 $\Omega$
1-4	.10	330 $\Omega$
1-8	.10	820 $\Omega$
1-11	.10	1500 $\Omega$
1-20	.10	10 K $\Omega$
1-21	.10	15 K $\Omega$
1-69	.10	18 K $\Omega$
1-22	.10	22 K $\Omega$
1-23	.10	27 K $\Omega$
1-67	.10	39 K $\Omega$
1-25	.10	47 K $\Omega$
1-26	.10	100 K $\Omega$
1-31	.10	330 K $\Omega$
1-32	.10	390 K $\Omega$

#### Precision 1%

2-94	2.10	.1 $\Omega$
2-226	2.10	.2162 $\Omega$
2-225	.75	.6838 $\Omega$
2-224	.50	2.162 $\Omega$
2-223	.50	6.838 $\Omega$
2-219	.40	21.62 $\Omega$
2-23	.25	68.38 $\Omega$
2-25	.20	216.2 $\Omega$
2-28	.20	683.8 $\Omega$
2-58	.20	1000 $\Omega$ (1 K $\Omega$ )
2-31	.20	2162 $\Omega$ (2.162 K $\Omega$ )
2-220	.35	3162 $\Omega$ (3.162 K $\Omega$ )
2-33	.20	6838 $\Omega$ (6.838 K $\Omega$ )
2-50	.20	10 K $\Omega$
2-39	.20	21.62 K $\Omega$
2-40	.20	68.38 K $\Omega$
2-42	.20	216.2 K $\Omega$
2-222	.40	306.2 K $\Omega$
2-45	.20	683.8 K $\Omega$
2-14	.20	1 M $\Omega$
2-146	.25	2.162 M $\Omega$
2-147	.40	6.838 M $\Omega$
2-221	.80	9.6838 M $\Omega$
2-17	.40	10 M $\Omega$

### CAPACITORS

#### Mica

20-102	.15	100 pf
20-108	.30	200 pf
20-113	.30	470 pf
20-107	.40	680 pf
20-122	.30	1000 pf
20-75	.70	5000 pf

PART No.	PRICE Each	DESCRIPTION
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### Other

21-72	.20	.005 $\mu$ fd disc
23-60	.35	.01 $\mu$ fd tubular
27-47	.15	.1 $\mu$ fd Mylar
25-54	.40	10 $\mu$ fd electrolytic
25-131	.90	250 $\mu$ fd electrolytic
31-30	1.05	1.5-7 pf trimmer
31-27	.85	8-50 pf trimmer

### CONTROLS-SWITCHES

10-52	.40	2000 $\Omega$ tab mount control
10-57	.35	10 K $\Omega$ tab mount control
10-60	.35	500 K $\Omega$ tab mount control
10-158	1.15	1000 $\Omega$ control
12-80	1.65	50 K $\Omega$ dual tandem control
63-430	3.85	9-position, 3-wafer switch (Volts Range)
63-431	5.00	3-position, 4-wafer switch (VOA Function)
63-520	4.20	3-position, 3-wafer switch (AC-DC Mode)
63-433	2.45	3-position, 1-wafer switch (On-Off Power)
63-434	2.10	7-position, 1-wafer switch (Ohms Range)
63-435	2.90	11-position, 1-wafer switch (MA Range)

### DIODES-TRANSISTORS

57-27	.60	Silicon diode
56-46	5.30	9.1 volt zener diode
56-32	1.50	13 volt zener diode
56-26	.30	1N191 crystal diode
417-118	.55	2N3393 transistor
417-140	1.50	2N4304 transistor

### METAL PARTS

90-346-2	3.35	Cabinet half shell
203-472-1	1.55	Front panel
203-473-1	1.45	Rear panel
203-474-1	.90	Subpanel
204-759-1	.20	End cap bracket
204-760-1	.65	Side rail bracket
204-761	.15	Circuit board mounting bracket
210-34	4.35	Front panel bezel
469-13	.10	Battery contactor

PART No.	PRICE Each	DESCRIPTION
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### WIRE

89-23	.80	Line cord
134-150	1.30	Cable assembly
341-1	.05/ft	Black test lead
343-11-1	.05/ft	Shielded test lead
344-15	.05/ft	Black stranded wire
344-16	.05/ft	Red stranded wire
344-59	.05/ft	Hookup wire

### #6 HARDWARE

250-162	.05	6-32 x 1/2" screw
250-365	.05	#6 x 1/4" sheet metal screw
250-116	.05	6-32 x 1/4" screw (black)
250-229	.05	6-32 x 1/4" phillips screw
250-303	.20	6-32 decorative screw
250-304	.15	6-32 x 7/16" spacer stud
250-305	.15	6-32 x 5/16" spacer stud
252-3	.05	6-32 nut
254-1	.05	#6 lockwasher
259-1	.05	#6 solder lug
259-11	.05	Spade lug

### OTHER HARDWARE

250-34	.05	4-40 x 1/2" screw
250-43	.05	8-32 x 1/4" setscrew
252-15	.05	4-40 nut
252-7	.05	Control nut
253-10	.05	Control flat washer
254-9	.05	#4 lockwasher
254-4	.05	Control lockwasher
255-29	.05	#4 spacer
252-73	.05	Speednut

### MISCELLANEOUS

54-177	2.55	Power transformer
73-27	.10	Plastic grommet (2 halves)
75-30	.10	Line cord strain relief (for round cord)
75-71	.10	Line cord strain relief (for flat cord)
85-169-1	5.00	Circuit board
211-32	.30	Handle
214-21	.50	Mercury cell holder
214-31	.30	Battery holder end
214-44	1.25	12-cell battery holder case
214-45	.90	2-cell battery holder case
258-30	.05	Battery contact spring
260-1	.15	Alligator clip
260-51	.20	Alligator clip with threaded insert

PART No.	PRICE Each	DESCRIPTION
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### Miscellaneous (cont'd.)

261-28	.10	Plastic foot
261-30	.10	Line cord retainer
262-8	.05	Terminal pin
352-13	.15	Silicone grease
407-117	10.10	200 microampere meter
412-15	.15	Neon lamp
413-10	.10	Pilot lamp lens
418-10	1.30	Mercury cell
431-2	.10	2-lug terminal strip
431-10	.10	3-lug terminal strip
436-20	.45	Phone jack
438-28	.65	Phone plug
455-50	.10	Knob bushing
462-245	.25	Knob
462-256	.65	Thumbwheel knob
432-27	.40	Line cord adapter
490-5	.10	Nut starter
331-6	.15	Solder
390-181	.15	12-cell battery label
390-182	.10	2-cell battery label
	2.00	Manual (See front cover for part number.)

To order parts, use the Parts Order Form furnished with this kit. If Parts Order Form is not available, refer to Replacement Parts in the Kit Builders Guide.

A factory-wired and tested replacement probe assembly, Model PKW-4, is available from Heath Company at \$4.95 plus postage. Due to the cost of handling, the replacement probe assembly is not available in kit form.

The above prices apply only on purchases from the Heath Company where shipment is to a U.S.A. destination. Add 10% (minimum 25 cents) to the price when ordering from a Heathkit Electronic Center to cover local sales tax, postage and handling. Outside the U.S.A. parts and service are available from your local Heathkit source and will reflect additional transportation, taxes, duties and rates of exchange.



## FUNCTIONAL PARTS LIST

R1 - 1 megohm 1% in probe for isolation - used only when measuring DC volts. Shorted out by probe switch for all other functions.

R2, R3, R4 - Input divider in AC Section - divides input voltage so that no more than 1.5 volts appears on gate of source follower Q1.

R5 - Current limiter for protection of Q1 (with Q2, Q3).

R6, R7 - Voltage divider across power supply - supplies correct bias to gate of Q1 - adjust R6 to produce 6 volt drop across R8.

R8 - Source resistor of AC input stage Q1.

R9, R10, R11 - Output divider in AC section - divides output voltage of Q1 so that no more than 150 mv appears on gate of source follower Q7. Works in conjunction with input divider to give 9 voltage ranges.

R12, R13 - Voltage divider across power supply - supplies correct voltage to base of Q12.

R14 - Emitter resistor Q12 - sets current through Q12 and hence through Q7.

R15, R21 - Collector (load) resistors of Q8, Q11.

R16, R19 - Emitter (load) resistors of Output stage Q9, Q10.

R17 - Adjustable series resistance for meter calibration (AC).

R18 - Adjustable series resistance for meter calibration (DC).

R20 - Adjustable series resistance for meter calibration (ohms).

R22, R23 - Voltage divider across power supply - provides proper bias voltage to base of Q11.

R24-R40 - DC voltage divider from R32 to R40 - Ohms divider from R24 to R40, milliamp divider from R24 to R34.

R41 - Maintains DC bias on gate of Q7 during AC operation - also provides voltage division for milliammeter circuit.

R42 - Forms overload protection circuit with Q5, Q6 - provides voltage division for milliammeter circuit - series current limiting resistor in gate of Q7 - maintains DC bias on gate of Q7 during AC operation.

R43 - Emitter resistor of Q4 - sets current through Q4 and hence supply voltage and/or current for ohms circuit.

R44-R47 - Voltage divider across power supply - supplies correct bias to gate of Q7 - adjust for proper zero of meter. R45 is Front Panel Zero Control.

R48 - Forms voltage divider with Q14, Q15 to supply bias voltage to base of Q13.

R49 - Emitter resistor of Q13 - sets current through Q13 and hence through Q8, Q11.

R50, R51 - Emitter resistors of Q8, Q11.

R52, R53 - Series dropping resistors in power supply - adjust current through zener diodes D6, D7.

R54 - Current limiter for pilot light.

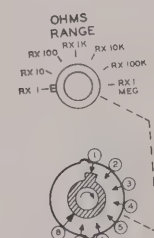
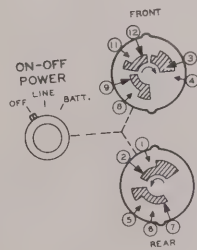
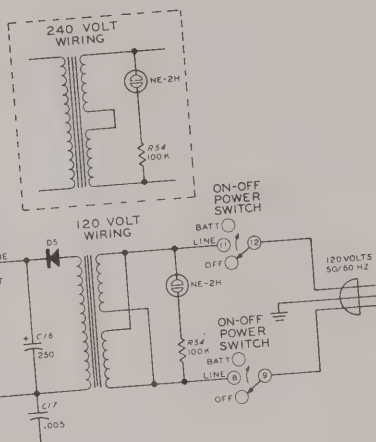
C1 - Input coupling capacitor - couples input signal to input AC divider R2-R4.

C2-C5 - Frequency compensation capacitors on input divider - adjust C2, C4 by application of square wave (1 kHz) to input readout with scope connected to output emitters (Q9, Q10).

C6 - Bypass capacitor across R5 - prevents loss of signal across R5 at higher frequencies.

C7 - Bypass capacitor provides "AC ground" to bottom of AC input divider.

C8 - Power Supply Bypass (filter) - shorts out test frequency signal on B+ line.



## FUNCTIONAL PARTS LIST

R1 - 1 megohm 1% in probe for isolation - used only when measuring DC volts. Shorted out by probe switch for all other functions.

R2, R3, R4 - Input divider in AC Section - divides input voltage so that no more than 1.5 volts appears on gate of source follower Q1.

R5 - Current limiter for protection of Q1 (with Q2, Q3).

R6, R7 - Voltage divider across power supply - supplies correct bias to gate of Q1 - adjust R6 to produce 6 volt drop across R8.

R8 - Source resistor of AC input stage Q1.

R9, R10, R11 - Output divider in AC section - divides output voltage of Q1 so that no more than 150 mv appears on gate of source follower Q7. Works in conjunction with input divider to give 9 voltage ranges.

R12, R13 - Voltage divider across power supply - supplies correct voltage to base of Q12.

R14 - Emitter resistor Q12 - sets current through Q12 and hence through Q7.

R15, R21 - Collector (load) resistors of Q8, Q11.

R16, R19 - Emitter (load) resistors of Output stage Q9, Q10.

R17 - Adjustable series resistance for meter calibration (AC).

R18 - Adjustable series resistance for meter calibration (DC).

R20 - Adjustable series resistance for meter calibration (ohms).

R22, R23 - Voltage divider across power supply - provides proper bias voltage to base of Q11.

R24-R40 - DC voltage divider from R32 to R40 - Ohms divider from R24 to R40, milliamp divider from R24 to R34.

R41 - Maintains DC bias on gate of Q7 during AC operation - also provides voltage division for milliammeter circuit.

R42 - Forms overload protection circuit with Q5, Q6 - provides voltage division for milliammeter circuit - series current limiting resistor in gate of Q7 - maintains DC bias on gate of Q7 during AC operation.

R43 - Emitter resistor of Q4 - sets current through Q4 and hence supply voltage and/or current for ohms circuit.

R44-R47 - Voltage divider across power supply - supplies correct bias to gate of Q7 - adjust for proper zero of meter. R45 is Front Panel Zero Control.

R48 - Forms voltage divider with Q14, Q15 to supply bias voltage to base of Q13.

R49 - Emitter resistor of Q13 - sets current through Q13 and hence through Q8, Q11.

R50, R51 - Emitter resistors of Q8, Q11.

R52, R53 - Series dropping resistors in power supply - adjust current through zener diodes D6, D7.

R54 - Current limiter for pilot light.

C1 - Input coupling capacitor - couples input signal to input AC divider R2-R4.

C2-C5 - Frequency compensation capacitors on input divider - adjust C2, C4 by application of square wave (1 kHz) to input readout with scope connected to output emitters (Q9, Q10).

C6 - Bypass capacitor across R5 - prevents loss of signal across R5 at higher frequencies.

C7 - Bypass capacitor provides "AC ground" to bottom of AC input divider.

C8 - Power Supply Bypass (filter) - shorts out test frequency signal on B+ line.



C9 - Coupling capacitor - couples signal at source of Q1 to output divider.

C10 - Coupling capacitor - couples signal at output of output divider to gate of Q7.

C11 - Compensates for losses in diode bridge at higher frequency.

C12 - Compensates for losses in base of Q11 at higher frequency.

C13 - Bypass capacitor - provides "AC ground" to ohms power supply - minimizes hum pickup during ohms measurement.

C14 - Bypass capacitor provides "AC ground" (hum reduction) to bottom of DC divider.

C15 - Compensates for losses across R50-R51 at higher frequency.

C16 - Power Supply charging capacitor - acts in conjunction with D5 to provide DC power supply.

C17 - "Grounding" capacitor - connects B- to meter cabinet.

D1-D4 - Bridge Rectifier - used for AC measurements to convert amplified signal to DC.

D5 - Power Supply Diode (rectifier) acts in conjunction with C16 to provide DC power supply.

D6 - Zener Diode - regulates output of power supply to 13 volts.

D7 - Zener Diode - regulates output of 13 volt diode to 9 volts.

Q1 - AC input source follower - provides isolation between input divider (R2-R4) and output divider (R9-R11) - provides high input impedance - low output impedance - forms integral part of AC divider system.

Q2, Q3 - Connected as back-to-back 9 volt zener protection diodes - when voltage at gate of Q1 exceeds 9 V (either polarity) conduction occurs through proper diode creating voltage drop across R5. Current limiting action of R5 provides some degree of protection to Q2, Q3.

Q4 - Constant current source for ohms circuit.

Q5, Q6 - Protection diodes (with R42) similar action to Q2, Q3 above - base-emitter connection used here to limit at .65 volts.

Q7 - DC input source follower - provides isolation between input divider (R24-R40) and amplifier circuit - provides high input impedance, low output impedance. Provides base bias to Q8. Couples AC input to amplifier circuit without loading divider R9-R11.

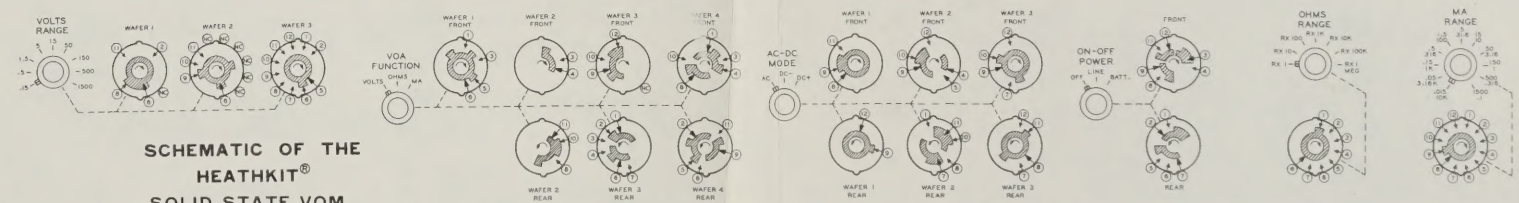
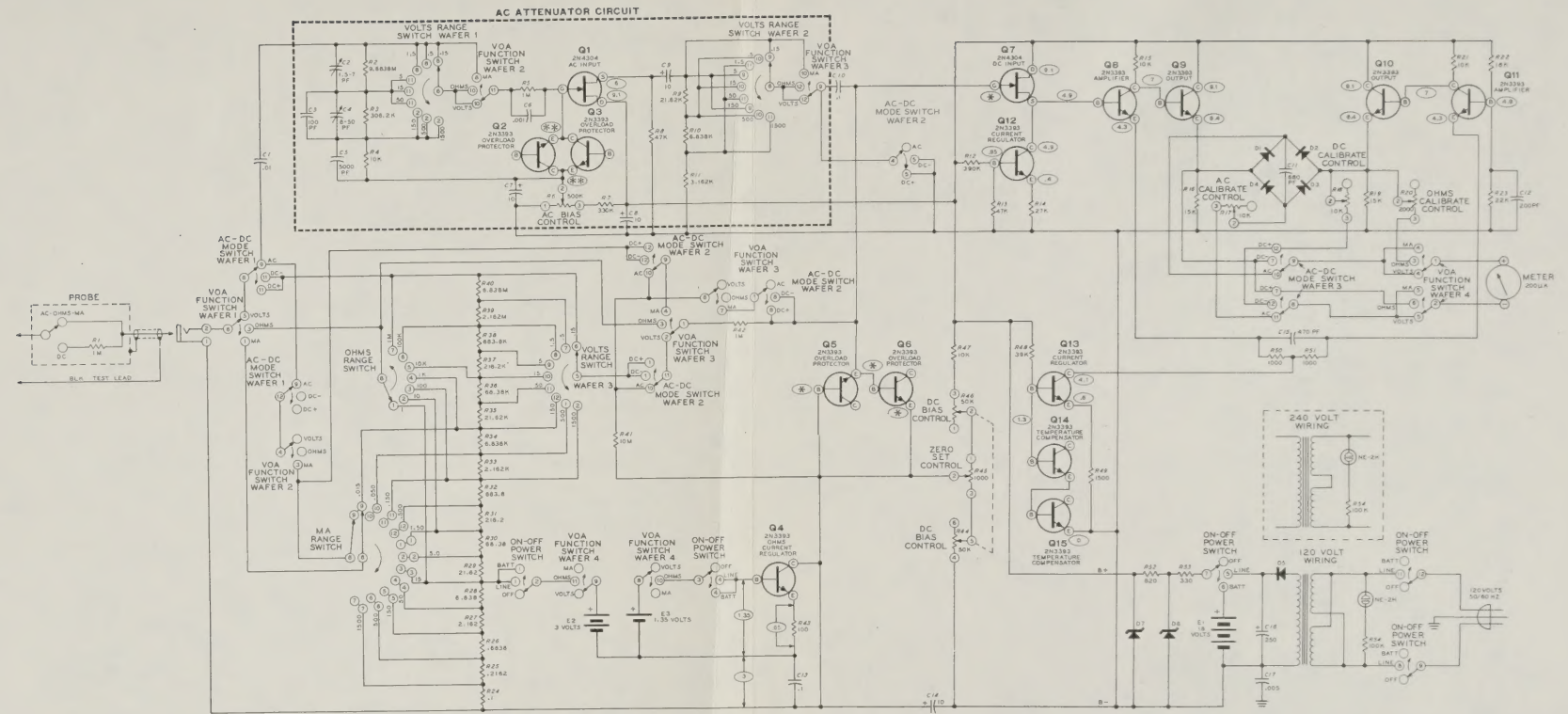
Q8, Q11 - Differential amplifier (balanced amplifier, long-tailed pair, etc.) provides sufficient gain to operate 200  $\mu$ A meter.

Q9, Q10 - Emitter follower output stage - provides isolation between amplifier and meter to prevent loading on amplifier.

Q12 - Constant current source supplying input FET Q7.

Q13 - Constant current source supplying amplifier transistors Q8, Q11.

Q14, Q15 - Connected as part of voltage divider (with R48) to supply base voltage to Q13 - used for temperature compensation of Q13.



SCHEMATIC OF THE  
HEATHKIT®  
SOLID STATE VOM  
MODEL IM-25

NOTES:

- ALL RESISTORS ARE 1/2 WATT UNLESS MARKED OTHERWISE, RESISTOR VALUES ARE IN OHMS (K = 1000, MEG = 1,000,000).
- ALL CAPACITOR VALUES ARE IN  $\mu$ F UNLESS MARKED OTHERWISE.
- THIS SYMBOL INDICATES A POSITIVE DC VOLTAGE MEASUREMENT, TAKEN WITH AN 11 MEGOHM VTVM, FROM THE POINT INDICATED TO B-. VOLTAGES MAY VARY  $\pm 20\%$ .
- VOLTAGES MEASURED WITH POWER SWITCH AT LINE OR BATT, AND VOA FUNCTION SWITCH AT OHMS.
- \* VOLTAGE DEPENDS UPON SETTING OF CONTROLS R44, R45, AND R46.
- \* \* VOLTAGE DEPENDS UPON SETTING OF CONTROL R6.
- ALL SWITCH WAFERS SHOWN IN FULL COUNTERCLOCKWISE POSITION, AS VIEWED FROM THE KNOB END OF THE SHAFT.
- ARROWS INDICATE CLOCKWISE ROTATION OF KNOB.
- REFER TO THE CHASSIS PHOTOGRAPHS AND CIRCUIT BOARD X-RAY VIEW FOR THE PHYSICAL LOCATION OF PARTS.



## FACTORY REPAIR SERVICE

You can return your completed kit to the Heath Company Service Department to have it repaired for a minimum service fee. (Kits that have been modified will not be accepted for repair.) If you wish, you can deliver your kit to a nearby Heath Authorized Service Center. These centers are listed in your Heathkit catalog.

To be eligible for replacement parts under the terms of the warranty, equipment returned for factory repair service, or delivered to a Heath Authorized Service Center, must be accompanied by the invoice or the sales slip, or a copy of either. If you send the original invoice or sales slip, it will be returned to you.

If it is not convenient to deliver your kit to a Heath Authorized Service Center, please ship it to the factory at Benton Harbor, Michigan and follow the following shipping instructions:

Prepare a letter in duplicate, containing the following information:

- Your name and return address.
- Date of purchase.
- A brief description of the difficulty.
- The invoice or sales slip, or a copy of either.
- Your authorization to ship the repaired unit back to you C.O.D. for the service and shipping charges, plus the cost of parts not covered by the warranty.

Attach the envelope containing one copy of this letter directly to the unit before packaging, so that we do not overlook this important information. Send the second copy of the letter by separate mail to Heath Company, Attention: Service Department, Benton Harbor, Michigan.

Check the equipment to see that all parts and screws are in place. (Do not include wooden cabinets when shipping receivers, tuners, amplifiers, or TV sets, as these are easily damaged in shipment.) Then, wrap the equipment in heavy paper. Place the equipment in a strong carton, and put at least **THREE INCHES** of resilient packing material (shredded paper, excelsior, etc.) on all sides, between the equipment and the carton. Seal the carton with gummed paper tape, and tie it with a strong cord. Ship it by prepaid express, United Parcel Service, or insured parcel post to:

Heath Company  
Service Department  
Benton Harbor, Michigan 49022







# HEATH COMPANY

BENTON HARBOR, MICHIGAN

**THE WORLD'S FINEST ELECTRONIC EQUIPMENT IN KIT FORM**

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